AUTOMATIC HOME STANDBY GENERATORS

DIAGNOSTIC REPAIR MANUAL

AIR-COOLED MODELS:

ASPAS1BBA007
(6 kW NG, 7 kW LP)

ASPAS1BBA012
(12 kW NG, 12 kW LP)

ASPAS1BBA015
(13 kW NG, 15 kW LP)

bryant®

SPECIFICATIONS

GENERATOR

	Model ASPAS1BBA007	Model ASPAS1BBA012	Model ASPAS1BBA015
Rated Max. Continuous Power Capacity (Watts*)	6,000 NG/7,000 LP	12,000 NG/12,000 LP	13,000 NG/15,000 LP
Rated Voltage	120/240	120/240	120/240
Rated Max. Continuous Load Current (Amps)			
120 Volts**	50.0 NG/58.3 LP	100.0 NG/100.0 LP	108.3 NG/125.0 LP
240 Volts	25.0 NG/29.2 LP	50.0 NG/50.0 LP	54.2 NG/62.5 LP
Main Line Circuit Breaker	30 Amp	50 Amp	70 Amp
Phase	1	1	1
Number of Rotor Poles	2	2	2
Rated AC Frequency	60 Hz	60 Hz	60 Hz
Power Factor	1	1	1
Battery Requirement	Group 26/26R 12 Volts and 350 Cold-cranking Amperes Minimum	Group 26/26R 12 Volts and 525 Cold-cranking Amperes Minimum	Group 26/26R 12 Volts and 525 Cold-cranking Amperes Minimum
Weight	375 Pounds	470 Pounds	487 Pounds
Output Sound Level @ 23 ft (7m) at full load	68 db (A)	70.5db (A)	71.5 db (A)
Normal Operating Range	-20°F (-28.8°C) to 104°F (40°C)		

* Maximum wattage and current are subject to and limited by such factors as fuel Btu content, ambient temperature, altitude, engine power and condition, etc. Maximum power decreases about 3.5 percent for each 1,000 feet above sea level; and also will decrease about 1 percent for each 6° C (10° F) above 16° C (60° F) ambient temperature.

** Load current values shown for 120 volts are maximum TOTAL values for two separate circuits. The maximum current in each circuit must not exceed the value stated for 240 volts.

ENGINE

	Model ASPAS1BBA007	Model ASPAS1BBA012	Model ASPAS1BBA015
Type of Engine	GH-410	GT-990	GT-990
Number of Cylinders	1	2	2
Rated Horsepower	14.5 @ 3,600 rpm	26 @ 3,600 rpm	30 @ 3,600 rpm
Displacement	410cc	992cc	992cc
Cylinder Block	Aluminum w/Cast Iron Sleeve	Aluminum w/Cast Iron Sleeve	Aluminum w/Cast Iron Sleeve
Valve Arrangement	Overhead Valves	Overhead Valves	Overhead Valves
Ignition System	Solid-state w/Magneto	Solid-state w/Magneto	Solid-state w/Magneto
Recommended Spark Plug	RC12YC	RC12YC	RC12YC
Spark Plug Gap	0.76 mm (0.030 inch)	0.5 mm (0.020 inch)	0.5 mm (0.020 inch)
Compression Ratio	8.6:1	9.5:1	9.5:1
Starter	12 Vdc	12 Vdc	12Vdc
Oil Capacity Including Filter	Approx. 1.5 Qts	Approx. 1.7 Qts	Approx. 1.7 Qts
Recommended Oil Filter	Part # 070185	Part # 070185	Part # 070185
Recommended Air Filter	Part # 0C8127	Part # 0C8127	Part # 0C8127
Operating RPM	3,600	3,600	3,600

FUEL CONSUMPTION

Model #	Natural Gas*		LP Vapor**	
	1/2 Load	Full Load	1/2 Load	Full Load
ASAPAS1BBA007	66	119	0.82/30	1.47/54
ASAPAS1BBA012	152	215	1.53/56	2.08/76
ASAPAS1BBA015	156	220	1.58/58	2.40/88

* Natural gas is in cubic feet per hour. **LP is in gallons per hour/cubic feet per hour.

STATOR WINDING RESISTANCE VALUES / ROTOR RESISTANCE

	Model ASPAS1BBA007	Model ASPAS1BBA012	Model ASPAS1BBA015
Power Winding: Across 11 & 22	0.223-0.259 ohms	0.115 ohms	0.08/0.08 ohms
Power Winding: Across 33 & 44	0.223-0.259 ohms	0.115 ohms	0.08/0.08 ohms
Excitation Winding: Across 2 & 6	1.53-1.77 ohms	0.745 ohms	0.705 ohms
Engine Run Winding: Across 55 & 66A	0.100-0.169 ohms	0.109 ohms	0.087 ohms
Battery Charge Winding: Across 66 & 77	0.146-0.169 ohms	0.164 ohms	0.130 ohms
Rotor Resistance	11.88-13.76 ohms	15.9 ohms	19.8 ohms

DIAGNOSTIC REPAIR MANUAL

Air-cooled, Prepackaged Automatic Standby Generators

Models:
6 kW NG, 7 kW LP
12 kW NG, 12 kW LP
13 kW NG, 15 kW LP

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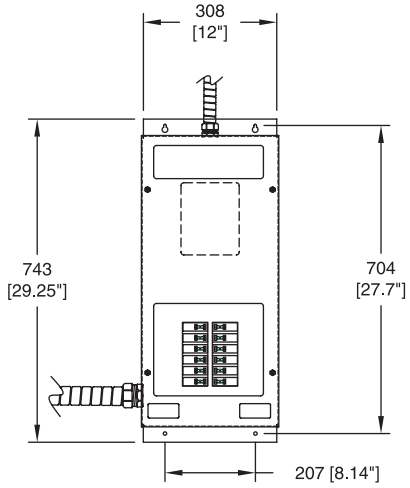
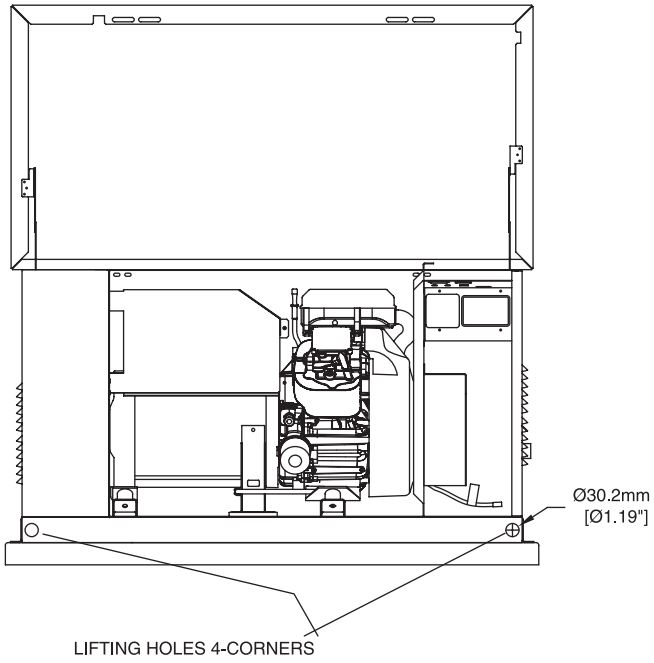
3	V-Type Prepackaged Transfer Switches
4	DC Control
5	Operational Tests and Adjustments
6	Disassembly
7	Electrical Data

SPECIFICATIONS

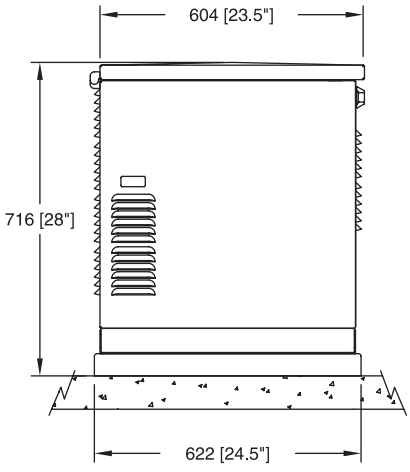
MOUNTING DIMENSIONS



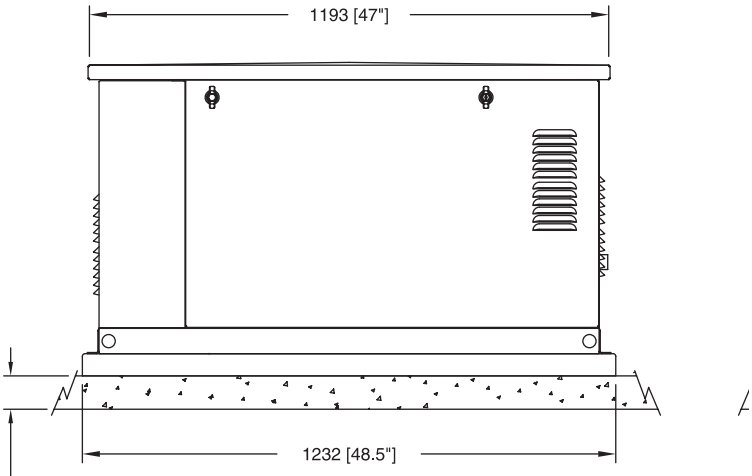
TRANSFER SWITCH
(IF SUPPLIED)



"DO NOT LIFT BY THE ROOF"



LEFT SIDE VIEW



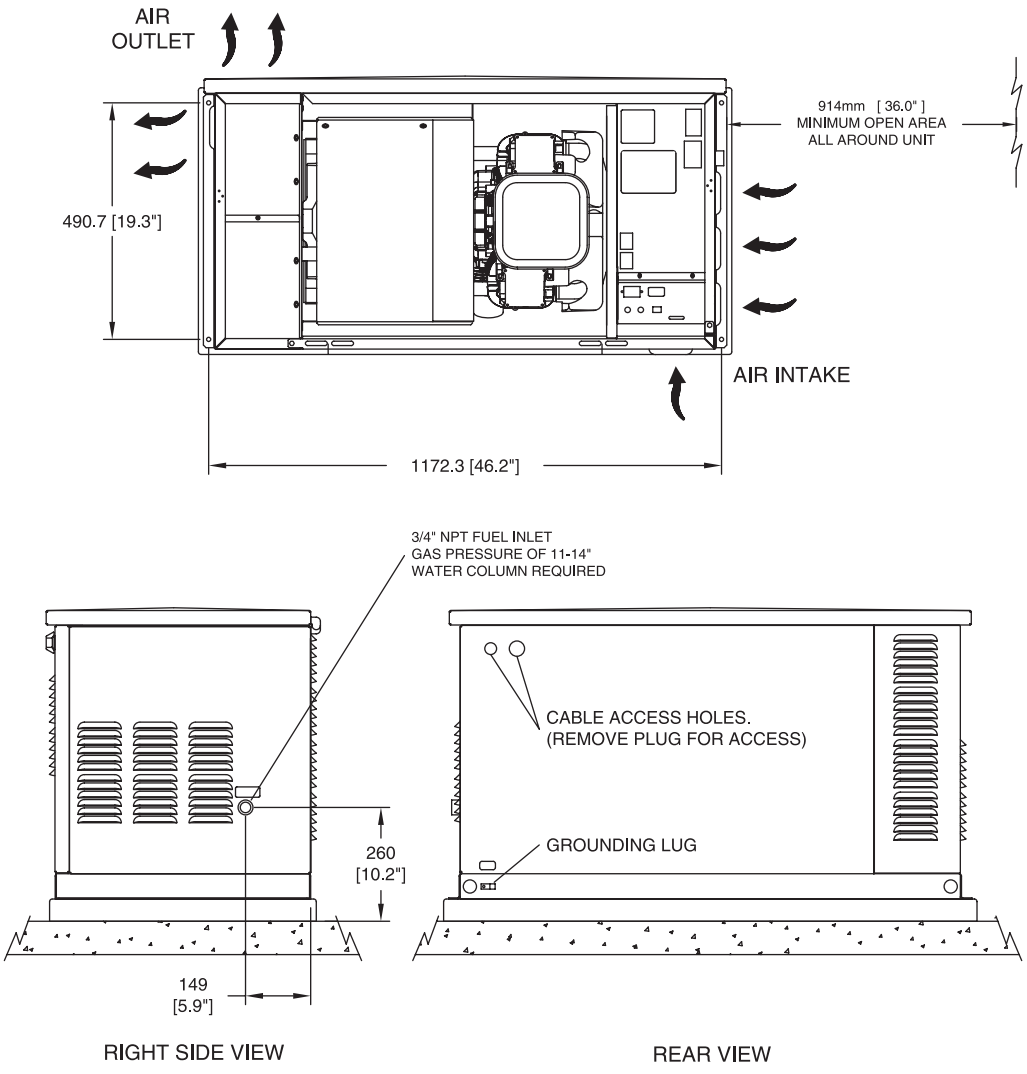
FRONT VIEW

76.2mm [3.00"]
PEA GRAVEL
MINUMUM

**ALL DIMENSIONS IN:
MILLIMETERS [INCHES]

HOME STANDBY GENERATOR
INSTALLATION DIAGRAM

MOUNTING DIMENSIONS

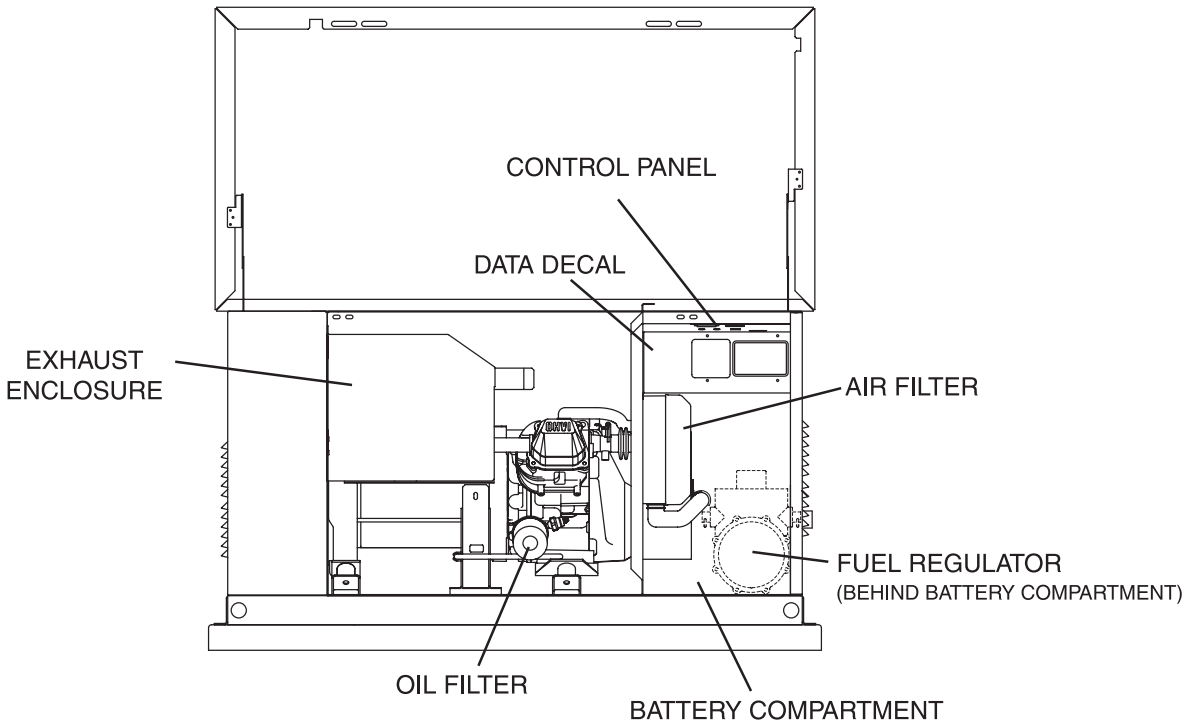


**ALL DIMENSIONS IN:
MILLIMETERS [INCHES]

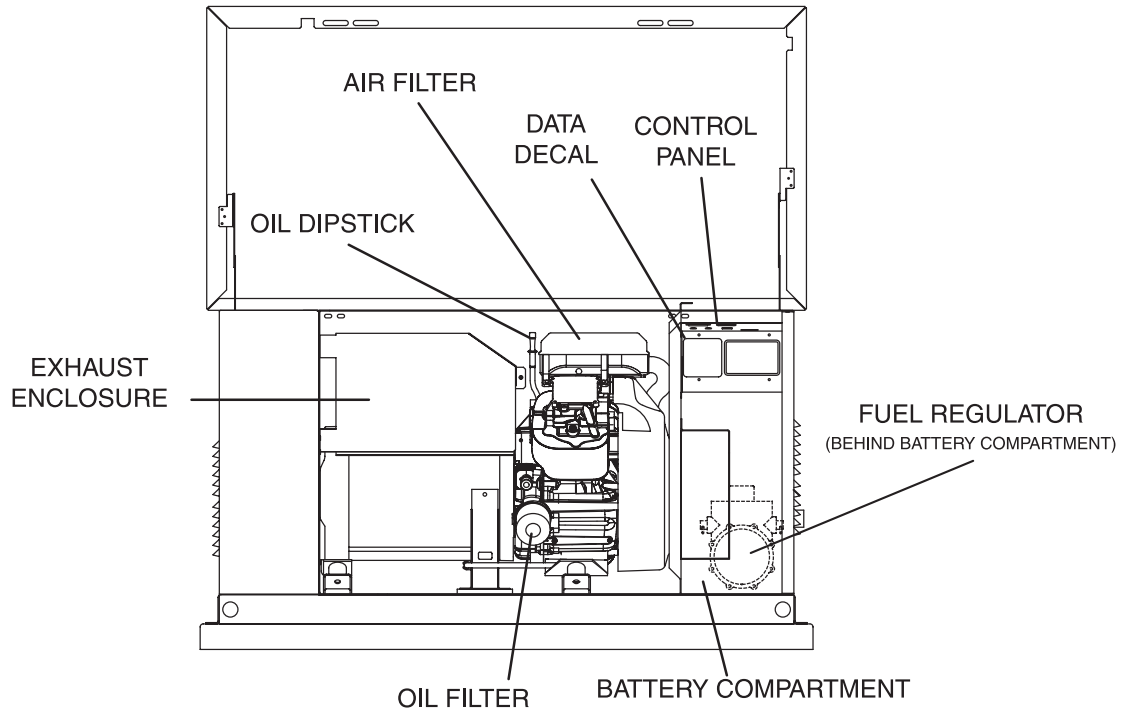
HOME STANDBY GENERATOR
INSTALLATION DIAGRAM

MAJOR FEATURES

7 kW, Single Cylinder GH-410 Engine



12 kW and 15 kW, V-twin GT-990 Engine



PART 1
GENERAL INFORMATION

Air-cooled, Prepackaged Automatic Standby Generators

Models:
6 kW NG, 7 kW LP
12 kW NG, 12 kW LP
13 kW NG, 15 kW LP

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1.2	Prepackaged Installation Basics
1.3	Preparation Before Use
1.4	Testing, Cleaning and Drying
1.5	Engine-Generator Protective Devices
1.6	Operating Instructions
1.7	Automatic Operating Parameters

INTRODUCTION

This Diagnostic Repair Manual has been prepared especially for the purpose of familiarizing service personnel with the testing, troubleshooting and repair of air-cooled, prepackaged automatic standby generators. Every effort has been expended to ensure that information and instructions in the manual are both accurate and current. However, Generac reserves the right to change, alter or otherwise improve the product at any time without prior notification.

The manual has been divided into ten PARTS. Each PART has been divided into SECTIONS. Each SECTION consists of two or more SUBSECTIONS.

It is not our intent to provide detailed disassembly and reassembly instructions in this manual. It is our intent to (a) provide the service technician with an understanding of how the various assemblies and systems work, (b) assist the technician in finding the cause of malfunctions, and (c) effect the expeditious repair of the equipment.

MODEL NUMBER:

Many home standby generators are manufactured to the unique specifications of the buyer. The Model Number identifies the specific generator set and its unique design specifications.

SERIAL NUMBER:

Used for warranty tracking purposes.

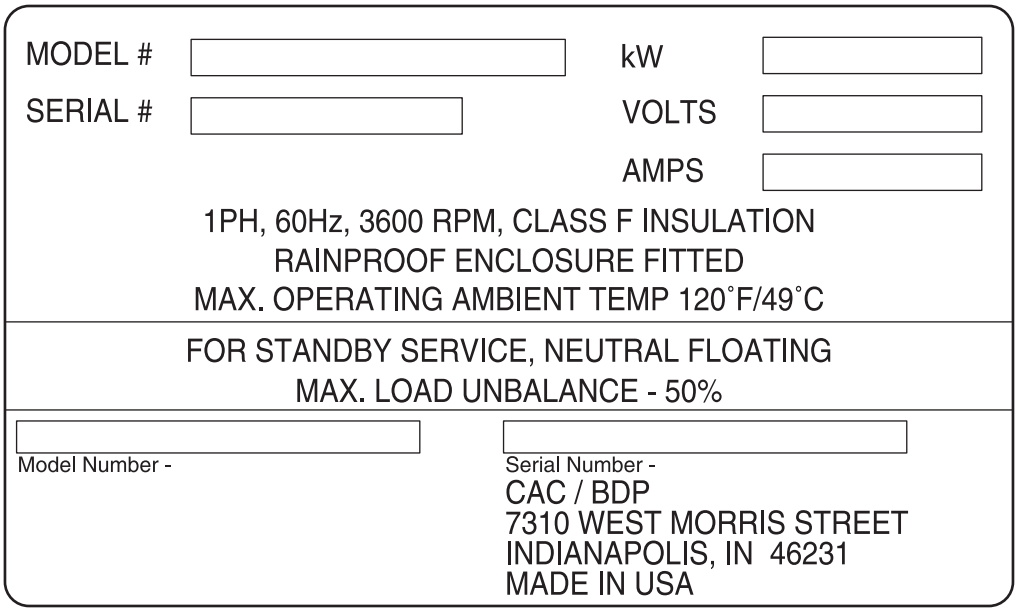


Figure 1. A Typical Data Plate

INTRODUCTION

Information in this section is provided so that the service technician will have a basic knowledge of installation requirements for prepackaged home standby systems. Problems that arise are often related to poor or unauthorized installation practices.

A typical prepackaged home standby electric system is shown in Figure 1 (next page). Installation of such a system includes the following:

- Selecting a Location
- Grounding the generator.
- Providing a fuel supply.
- Mounting the load center.
- Connecting power source and load lines.
- Connecting system control wiring.
- Post installation tests and adjustments.

SELECTING A LOCATION

Install the generator set as close as possible to the electrical load distribution panel(s) that will be powered by the unit, ensuring that there is proper ventilation for cooling air and exhaust gases. This will reduce wiring and conduit lengths. Wiring and conduit not only add to the cost of the installation, but excessively long wiring runs can result in a voltage drop.

GROUNDING THE GENERATOR

The National Electric Code requires that the frame and external electrically conductive parts of the generator be property connected to an approved earth ground. Local electrical codes may also require proper grounding of the unit. For that purpose, a grounding lug is attached to the unit. Grounding may be accomplished by attaching a stranded copper wire of the proper size to the generator grounding lug and to an earth-driven copper or brass grounding-rod (electrode). Consult with a local electrician for grounding requirements in your area.

THE FUEL SUPPLY

Prepackaged units with air-cooled engine were operated, tested and adjusted at the factory using natural gas as a fuel. These air-cooled engine units can be converted to use LP (propane) gas by making a few adjustments for best operation and power.

LP (propane) gas is usually supplied as a liquid in pressure tanks. Both the air-cooled and the liquid cooled units require a "vapor withdrawal" type of fuel supply system when LP (propane) gas is used. The vapor withdrawal system utilizes the gaseous fuel vapors that form at the top of the supply tank.

The pressure at which LP gas is delivered to the generator fuel solenoid valve may vary considerably, depending on ambient temperatures. In cold weather, supply pressures may drop to "zero". In warm weather, extremely high gas pressures may be encountered. A primary regulator is required to maintain correct gas supply pressures.

Recommended gaseous fuel pressure at the inlet side of the generator fuel solenoid valve is as follows:

	LP	NG
Minimum water column	11 inches	5 inches
Maximum water column	14 inches	7 inches

A primary regulator is required to ensure that proper fuel supply pressures are maintained.

DANGER: LP AND NATURAL GAS ARE BOTH HIGHLY EXPLOSIVE. GASEOUS FUEL LINES MUST BE PROPERLY PURGED AND TESTED FOR LEAKS BEFORE THIS EQUIPMENT IS PLACED INTO SERVICE AND PERIODICALLY THEREAFTER. PROCEDURES USED IN GASEOUS FUEL LEAKAGE TESTS MUST COMPLY STRICTLY WITH APPLICABLE FUEL GAS CODES. DO NOT USE FLAME OR ANY SOURCE OF HEAT TO TEST FOR GAS LEAKS. NO GAS LEAKAGE IS PERMITTED. LP GAS IS HEAVIER THAN AIR AND TENDS TO SETTLE IN LOW AREAS. NATURAL GAS IS LIGHTER THAN AIR AND TENDS TO SETTLE IN HIGH PLACES. EVEN THE SLIGHTEST SPARK CAN IGNITE THESE FUELS AND CAUSE AN EXPLOSION.

Use of a flexible length of hose between the generator fuel line connection and rigid fuel lines is required. This will help prevent line breakage that might be caused by vibration or if the generator shifts or settles. The flexible fuel line must be approved for use with gaseous fuels.

Flexible fuel line should be kept as straight as possible between connections. The bend radius for flexible fuel line is nine (9) inches. Exceeding the bend radius can cause the fittings to crack.

THE TRANSFER SWITCH / LOAD CENTER

A transfer switch is required by electrical code, to prevent electrical feedback between the utility and standby power sources, and to transfer electrical loads from one power supply to another safely.

PREPACKAGED TRANSFER SWITCHES:

Instructions and information on prepackaged transfer switches may be found in Part 3 of this manual.

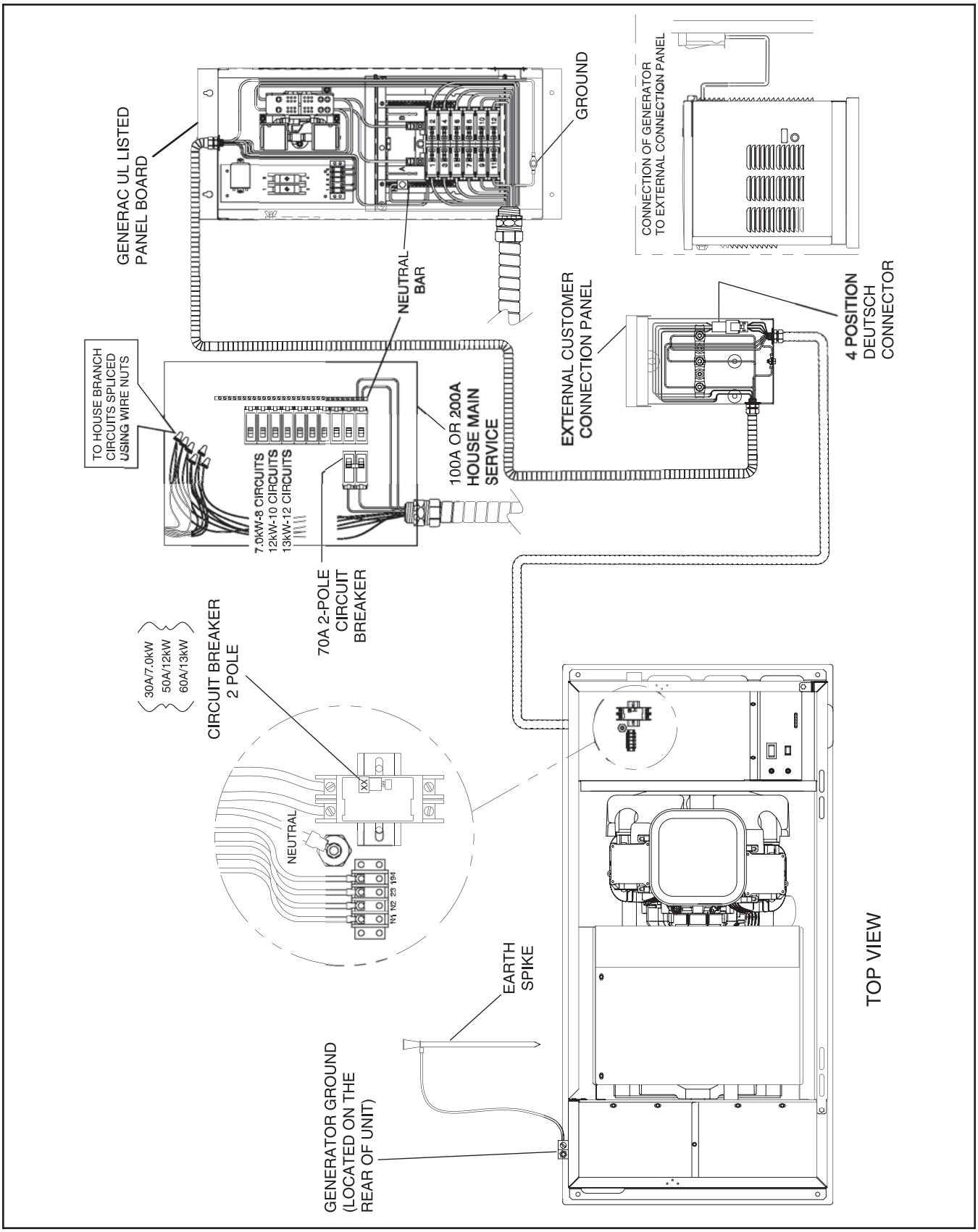


Figure 1. Typical Prepackaged Installation

POWER SOURCE AND LOAD LINES

The utility power supply lines, the standby (generator) supply lines, and electrical load lines must all be connected to the proper terminal lugs in the transfer switch. The following rules apply:In 1-phase systems with a 2-pole transfer switch, connect the two utility source hot lines to Transfer Switch Terminal Lugs N1 and N2. Connect the standby source hot lines (E1, E2) to Transfer Switch Terminal Lugs E1 and E2. Connect the load lines from Transfer Switch Terminal Lugs T1 and T2 to the electrical load circuit. Connect UTILITY, STANDBY and LOAD neutral lines to the neutral block in the transfer switch.

SYSTEM CONTROL INTERCONNECTIONS

Prepackaged home standby generators are equipped with a terminal board identified with the following terminals: (a) utility 1, (b) utility 2, (c) 23, and (d) 194. Prepackaged load centers house an identically marked terminal board. When these four terminals are properly interconnected, dropout of utility source voltage below a preset value will result in automatic generator startup and transfer of electrical loads to the "Standby" source. On restoration of utility source voltage above a preset value will result in retransfer back to that source and generator shutdown.

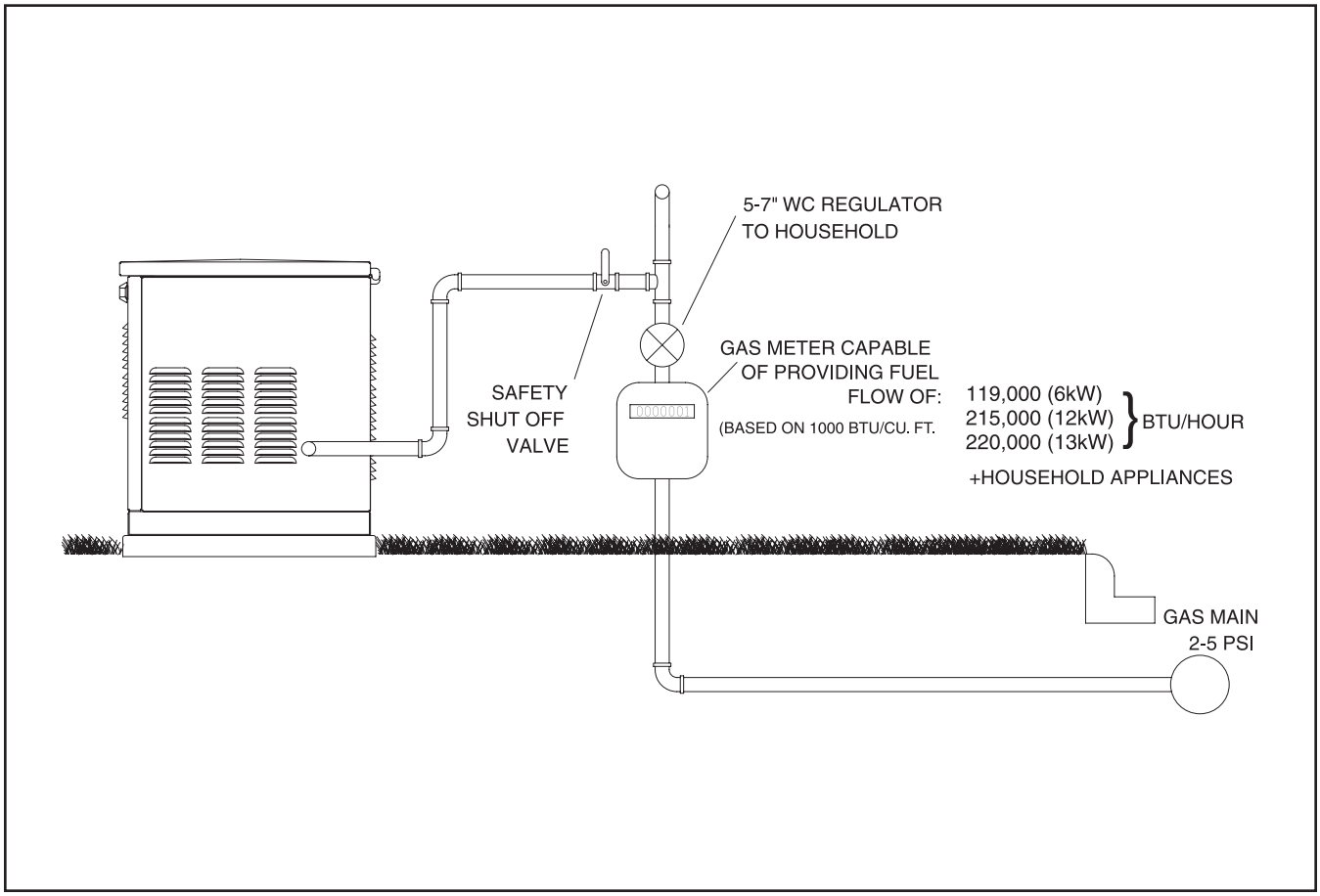


Figure 2. Proper Fuel Installation

GENERAL

The installer must ensure that the home standby generator has been properly installed. The system must be inspected carefully following installation. All applicable codes, standards and regulations pertaining to such installations must be strictly complied with. In addition, regulations established by the Occupational Safety and Health Administration (OSHA) must be complied with.

Prior to initial startup of the unit, the installer must ensure that the engine-generator has been properly prepared for use. This includes the following:

- An adequate supply of the correct fuel must be available for generator operation.
- The engine must be properly serviced with the recommended oil.

FUEL REQUIREMENTS

Generators with air-cooled engine have been factory tested and adjusted using natural gas as a fuel. If LP (propane) gas is to be used at the installation site, adjustment of the generator fuel regulator will be required for best performance. Refer to Test 63, "Check Fuel Regulator" for fuel regulator adjustment procedures.

- When natural gas is used as a fuel, it should be rated at least 1000 BTU's per cubic foot.
- When LP (propane) gas is used as a fuel, it should be rated at 2520 BTU's per cubic foot.

ENGINE OIL RECOMMENDATIONS

The primary recommended oil for units with air-cooled, single cylinder or V-Twin engines is synthetic oil. Synthetic oil provides easier starts in cold weather and maximum engine protection in hot weather. Use high quality detergent oil that meets or exceeds API (American Petroleum Institute) Service class SG, SH, or SJ requirements for gasoline engines. The following chart lists recommended viscosity ranges for the lowest anticipated ambient temperatures.

Engine crankcase oil capacities for the engines covered in this manual can be found in the specifications section at the beginning of the book.

Use SAE 5W-30 Synthetic oil for all seasons.

VISUAL INSPECTION

When it becomes necessary to test or troubleshoot a generator, it is a good practice to complete a thorough visual inspection. Remove the access covers and look closely for any obvious problems. Look for the following:

- Burned or broken wires, broken wire connectors, damaged mounting brackets, etc.
- Loose or frayed wiring insulation, loose or dirty connections.
- Check that all wiring is well clear of rotating parts.
- Verify that the Generator properly connected for the correct rated voltage. This is especially important on new installations. See Section 1.2, "AC Connection Systems".
- Look for foreign objects, loose nuts, bolts and other fasteners.
- Clean the area around the Generator. Clear away paper, leaves, snow, and other objects that might blow against the generator and obstruct its air openings.

METERS

Devices used to measure electrical properties are called meters. Meters are available that allow one to measure (a) AC voltage, (b) DC voltage, (c) AC frequency, and (d) resistance In ohms. The following apply:

- To measure AC voltage, use an AC voltmeter.
- To measure DC voltage, use a DC voltmeter.
- Use a frequency meter to measure AC frequency In "Hertz" or "cycles per second".
- Use an ohmmeter to read circuit resistance, in "ohms".

THE VOM

A meter that will permit both voltage and resistance to be read is the "volt-ohm-milliammeter" or "VOM".

Some VOM's are of the analog type (not shown). These meters display the value being measured by physically deflecting a needle across a graduated scale. The scale used must be interpreted by the user.

Digital VOM's (Figure 1) are also available and are generally very accurate. Digital meters display the measured values directly by converting the values to numbers.

NOTE: Standard AC voltmeters react to the AVERAGE value of alternating current. When working with AC, the effective value is used. For that reason a different scale is used on an AC voltmeter. The scale is marked with the effective or "rms" value even though the meter actually reacts to the average value. That is why the AC voltmeter will give an Incorrect reading if used to measure direct current (DC).

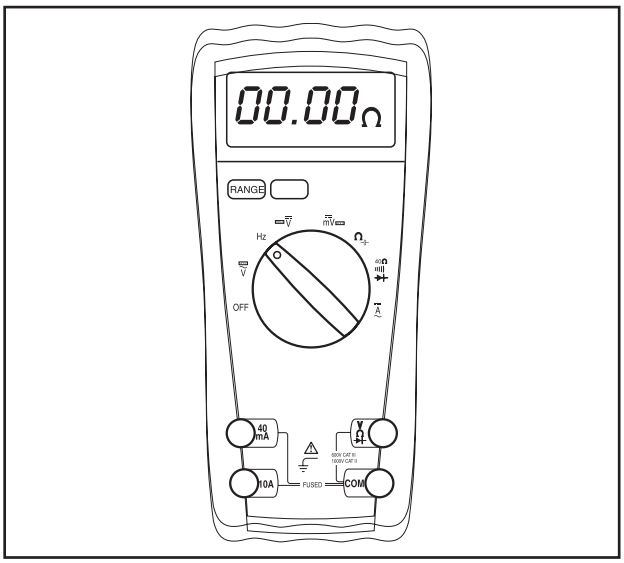


Figure 1. Digital VOM

MEASURING AC VOLTAGE

An accurate AC voltmeter or a VOM may be used to read the generator AC output voltage. The following apply:

1. Always read the generator AC output voltage only at the unit's rated operating speed and AC frequency.
2. The generator voltage regulator can be adjusted for correct output voltage only while the unit is operating at its correct rated speed and frequency.
3. Only an AC voltmeter may be used to measure AC voltage. DO NOT USE A DC VOLTMETER FOR THIS PURPOSE.

DANGER!: GENERATORS PRODUCE HIGH AND DANGEROUS VOLTAGES. CONTACT WITH HIGH VOLTAGE TERMINALS WILL RESULT IN DANGEROUS AND POSSIBLY LETHAL ELECTRICAL SHOCK.

MEASURING DC VOLTAGE

A DC voltmeter or a VOM may be used to measure DC voltages. Always observe the following rules:

1. Always observe correct DC polarity.
   a. Some VOM's may be equipped with a polarity switch.
   b. On meters that do not have a polarity switch, DC polarity must be reversed by reversing the test leads.

2. Before reading a DC voltage, always set the meter to a higher voltage scale than the anticipated reading. if in doubt, start at the highest scale and adjust the scale downward until correct readings are obtained.
3. The design of some meters is based on the "current flow" theory while others are based on the "electron flow" theory.
   a. The "current flow" theory assumes that direct current flows from the positive (+) to the negative (-).
   b. The "electron flow" theory assumes that current flows from negative (-) to positive (+).

NOTE: When testing generators, the "current flow" theory is applied. That is, current is assumed to flow from positive (+) to negative (-).

MEASURING AC FREQUENCY

The generator AC output frequency is proportional to rotor speed. Generators equipped with a 2-pole rotor must operate at 3600 rpm to supply a frequency of 60 Hertz. Units with 4-pole rotor must run at 1800 rpm to deliver 60 Hertz.

Correct engine and rotor speed is maintained by an engine speed governor. For models rated 60 Hertz, the governor is generally set to maintain a no-load frequency of about 62 Hertz with a corresponding output voltage of about 124 volts AC line-to-neutral. Engine speed and frequency at no-load are set slightly high to prevent excessive rpm and frequency droop under heavy electrical loading.

MEASURING CURRENT

To read the current flow, in AMPERES, a clamp-on ammeter may be used. This type of meter indicates current flow through a conductor by measuring the strength of the magnetic field around that conductor. The meter consists essentially of a current transformer with a split core and a rectifier type instrument connected to the secondary. The primary of the current transformer is the conductor through which the current to be measured flows. The split core allows the Instrument to be clamped around the conductor without disconnecting it.

Current flowing through a conductor may be measured safely and easily. A line-splitter can be used to measure current in a cord without separating the conductors.

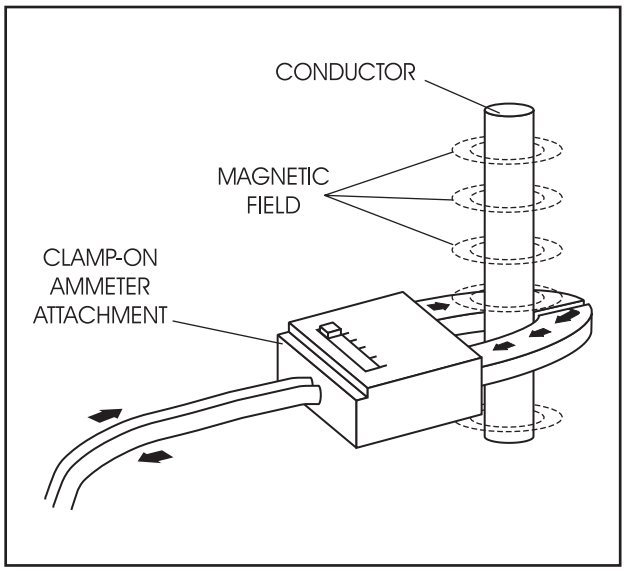


Figure 2. Clamp-On Ammeter

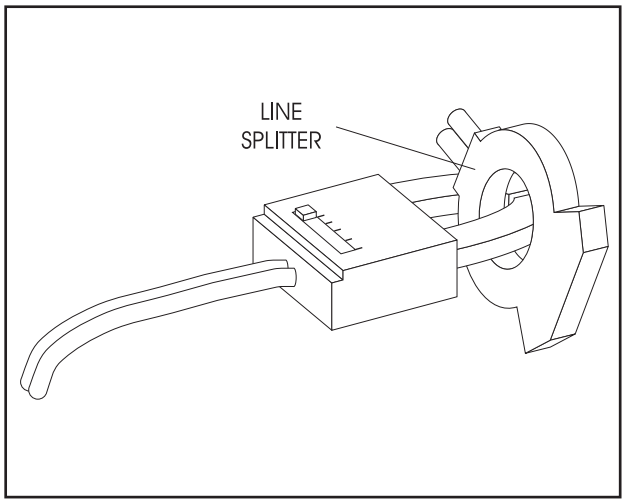


Figure 3. A Line-Splitter

NOTE: If the physical size of the conductor or ammeter capacity does not permit all lines to be measured simultaneously, measure current flow in each individual line. Then, add the Individual readings.

MEASURING RESISTANCE

The volt-ohm-milliammeter may be used to measure the resistance in a circuit. Resistance values can be very valuable when testing coils or windings, such as the stator and rotor windings.

When testing stator windings, keep in mind that the resistance of these windings is very low. Some meters are not capable of reading such a low resistance and will simply read CONTINUITY.

If proper procedures are used, the following conditions can be detected using a VOM:

- A "short-to-ground" condition in any stator or rotor winding.
- Shorting together of any two parallel stator windings.
- Shorting together of any two isolated stator windings.
- An open condition in any stator or rotor winding.

Component testing may require a specific resistance value or a test for INFINITY or CONTINUITY. Infinity is an OPEN condition between two electrical points, which would read as no resistance on a VOM. Continuity is a closed condition between two electrical points, which would be indicated as very low resistance or ZERO on a VOM.

ELECTRICAL UNITS

AMPERE:

The rate of electron flow in a circuit is represented by the AMPERE. The ampere is the number of electrons flowing past a given point at a given time. One AMPERE is equal to just slightly more than six thousand million billion electrons per second.

With alternating current (AC), the electrons flow first in one direction, then reverse and move in the opposite direction. They will repeat this cycle at regular intervals. A wave diagram, called a "sine wave" shows that current goes from zero to maximum positive value, then reverses and goes from zero to maximum negative value. Two reversals of current flow is called a cycle. The number of cycles per second is called frequency and is usually stated in "Hertz".

VOLT:

The VOLT is the unit used to measure electrical PRESSURE, or the difference in electrical potential that causes electrons to flow. Very few electrons will flow when voltage is weak. More electrons will flow as voltage becomes stronger. VOLTAGE may be considered to be a state of unbalance and current flow as an attempt to regain balance. One volt is the amount of EMF that will cause a current of 1 ampere to flow through 1 ohm of resistance.

OHM:

The OHM is the unit of RESISTANCE. In every circuit there is a natural resistance or opposition to the flow of electrons. When an EMF is applied to a complete circuit, the electrons are forced to flow in a single direction rather than their free or orbiting pattern. The resistance of a conductor depends on (a) its physical makeup, (b) its cross-sectional area, (c) its length, and (d) its temperature. As the conductor's temperature increases, its resistance increases in direct proportion. One (1) ohm of resistance will permit one (1) ampere of current to flow when one (1) volt of electromotive force (EMF) is applied.

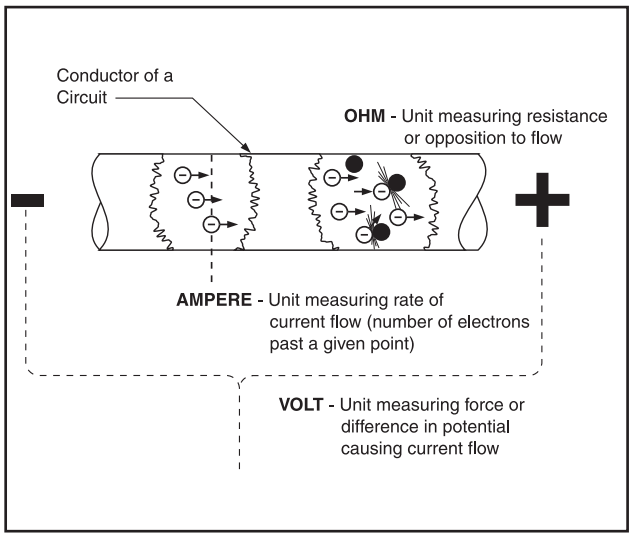

Conductor of a Circuit
OHM - Unit measuring resistance or opposition to flow
AMPERE - Unit measuring rate of current flow (number of electrons past a given point)
VOLT - Unit measuring force or difference in potential causing current flow

Figure 4. Electrical Units

OHM'S LAW

A definite and exact relationship exists between VOLTS, OHMS and AMPERES. The value of one can be calculated when the value of the other two are known. Ohm's Law states that in any circuit the current will increase when voltage increases but resistance remains the same, and current will decrease when resistance Increases and voltage remains the same.

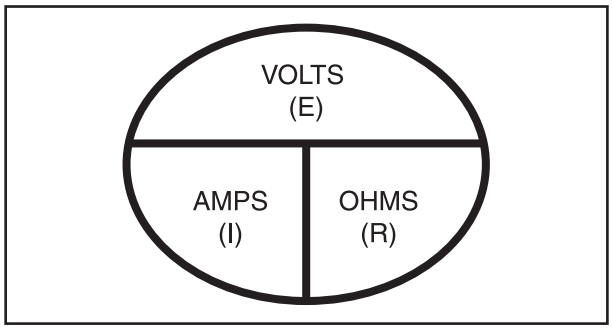


Figure 5.

If AMPERES is unknown while VOLTS and OHMS are known, use the following formula:

$$AMPERES = \frac{VOLTS}{OHMS}$$

If VOLTS is unknown while AMPERES and OHMS are known, use the following formula:

$$VOLTS = AMPERES \times OHMS$$

If OHMS is unknown but VOLTS and AMPERES are known, use the following:

$$OHMS = \frac{VOLTS}{AMPERES}$$

INSULATION RESISTANCE

The insulation resistance of stator and rotor windings is a measurement of the integrity of the insulating materials that separate the electrical windings from the generator steel core. This resistance can degrade over time or due to such contaminants as dust, dirt, oil, grease and especially moisture. In most cases, failures of stator and rotor windings is due to a breakdown in the insulation. And, in many cases, a low insulation resistance is caused by moisture that collects while the generator is shut down. When problems are caused by moisture buildup on the windings, they can usually be corrected by drying the windings. Cleaning and drying the windings can usually eliminate dirt and moisture built up in the generator windings.

THE MEGOHMMETER

GENERAL:

A megohmmeter, often called a "megger", consists of a meter calibrated in megohms and a power supply. Use a power supply of 500 volts when testing stators or rotors. DO NOT APPLY VOLTAGE LONGER THAN ONE (1) SECOND.

TESTING STATOR INSULATION:

All parts that might be damaged by the high megger voltages must be disconnected before testing. Isolate all stator leads (Figure 2) and connect all of the stator leads together. FOLLOW THE MEGGER MANUFACTURER'S INSTRUCTIONS CAREFULLY.

Use a megger power setting of 500 volts. Connect one megger test lead to the junction of all stator leads, the other test lead to frame ground on the stator can. Read the number of megohms on the meter.

$$\text{MINIMUM INSULATION RESISTANCE (in "Megohms")} = \frac{\text{GENERATOR RATED VOLTS}}{1000} + 1$$

The MINIMUM acceptable megger reading for stators may be calculated using the following formula:

EXAMPLE: Generator is rated at 120 volts AC. Divide "120" by "1000" to obtain "0.12". Then add "1" to obtain "1.12" megohms. Minimum Insulation resistance for a 120 VAC stator is 1.12 megohms.

If the stator insulation resistance is less than the calculated minimum resistance, clean and dry the stator. Then, repeat the test. If resistance is still low, replace the stator.

Use the Megger to test for shorts between isolated windings as outlined "Stator Insulation Tests".

Also test between parallel windings. See "Test Between Parallel Windings" on next page.

TESTING ROTOR INSULATION:

Apply a voltage of 500 volts across the rotor positive (+) slip ring (nearest the rotor bearing), and a clean frame ground (i.e. the rotor shaft). DO NOT EXCEED 500 VOLTS AND DO NOT APPLY VOLTAGE LONGER THAN 1 SECOND. FOLLOW THE MEGGER MANUFACTURER'S INSTRUCTIONS CAREFULLY.

ROTOR MINIMUM INSULATION RESISTANCE:

1.5 megohms

CAUTION: BEFORE ATTEMPTING TO MEASURE INSULATION RESISTANCE, FIRST DISCONNECT AND ISOLATE ALL LEADS OF THE WINDING TO BE TESTED. ELECTRONIC COMPONENTS, DIODES, SURGE PROTECTORS, RELAYS, VOLTAGE REGULATORS, ETC., CAN BE DESTROYED IF SUBJECTED TO HIGH MEGGER VOLTAGES.

HI-POT TESTER:

A "Hi-Pot" tester is shown in Figure 1. The model shown is only one of many that are commercially available. The tester shown is equipped with a voltage selector switch that permits the power supply voltage to be selected. It also mounts a breakdown lamp that will illuminate to indicate an insulation breakdown during the test.

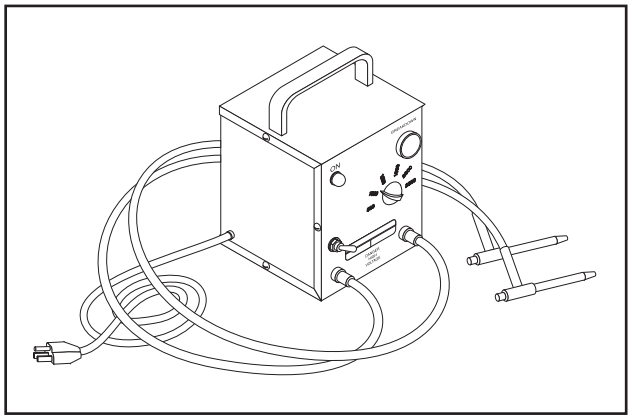


Figure 1. One Type of Hi-Pot Tester

STATOR INSULATION RESISTANCE TEST

GENERAL:

Units with air-cooled engines are equipped with (a) dual stator AC power windings, (b) an excitation or DPE winding, (c) a battery charge winding and (d) an engine run winding. Insulation tests of the stator consist of (a) testing all windings to ground, (b) testing between isolated windings, and (c) testing between

parallel windings. Figure 2 is a pictorial representation of the various stator leads on units with air-cooled engine.

TESTING ALL STATOR WINDINGS TO GROUND:

1. Disconnect stator output leads 11 and 44 from the generator main line circuit breaker.
2. Remove stator output leads 22 and 33 from the neutral connection and separate the two leads.
3. Disconnect C2 connector from the side of the control panel. The C2 connector is the closest to the back panel. See Figure 9, page 128 for connector location.

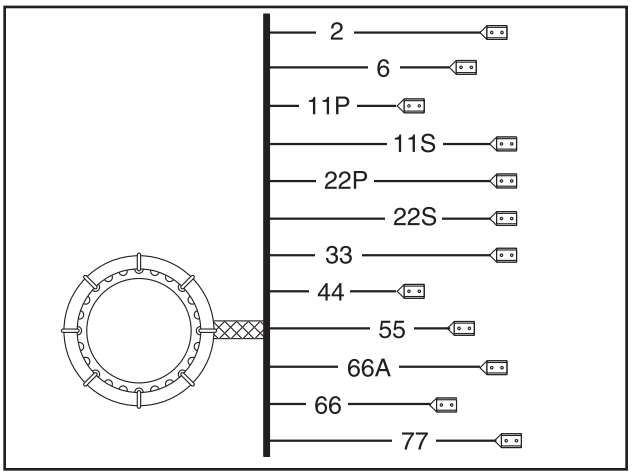


Figure 2. Stator Winding Leads

4. Connect the terminal ends of Wires 11, 22, 33 and 44 together. Make sure the wire ends are not touching any part of the generator frame or any terminal.
5. Connect the red test probe of the Hi-Pot tester to the joined terminal ends of stator leads 11, 22, 33 and 44. Connect the black tester lead to a clean frame ground on the stator can. With tester leads connected in this manner, proceed as follows:
   a. Turn the Hi-Pot tester switch OFF.
   b. Plug the tester cord into a 120 volt AC wall socket and set its voltage selector switch to "1500 volts".
   c. Turn the tester switch "On" and observe the breakdown lamp on tester. DO NOT APPLY VOLTAGE LONGER THAN 1 SECOND. After one (1) second, turn the tester switch OFF.

If the breakdown lamp comes on during the one-second test, the stator should be cleaned and dried. After cleaning and drying, repeat the insulation test. If, after cleaning and drying, the stator fails the second test, the stator assembly should be replaced.

6. Now proceed to the C2 connector. Each winding will be individually tested for a short to ground. Insert a large paper clip (or similar item) into the C2 connector at the following pin locations:

Pin Location	Wire Number	Winding
1	77	Battery Charge
2	66	Battery Charge
3	66A	Engine Run
4	55	Engine Run
5	22	Sense Lead Power
6	11	Sense Lead Power
7	6	Excitation
8	2	Excitation

Next refer to Steps 5a through 5c of the Hi-Pot procedure.

Example: Insert paper clip into Pin 1, Hi-Pot from Pin 1 (Wire 77) to ground. Proceed to Pin 2, Pin 3, etc. through Pin 8.

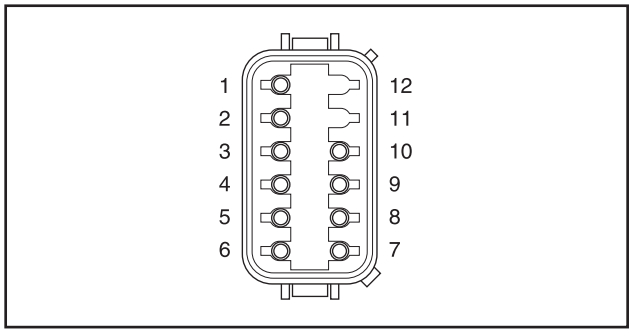


Figure 3. C2 Connector Pin Location Numbers (Female Side)

TEST BETWEEN WINDINGS:

1. Insert a large paper clip into Pin Location 1 (Wire 77). Connect the red tester probe to the paper clip. Connect the black tester probe to Stator Lead 11. Refer to Steps 5a through 5c of “TESTING ALL STATOR WINDINGS TO GROUND” on the this page.
2. Repeat Step 1 at Pin Location 3 (Wire 66A) and Stator Lead 11.
3. Repeat Step 1 at Pin Location 7 (Wire 6). and Stator Lead 11.
4. Connect the red test probe to Stator Lead 33. Connect the black test probe to Stator Lead 11. Refer to Steps 5a through 5c of “TESTING ALL STATOR WINDINGS TO GROUND” on the this page.

5. Insert a large paper clip into Pin Location No. 1 (Wire 77). Connect the red tester probe to the paper clip. Connect the black tester probe to Stator Lead 33. Refer to Steps 5a through 5c of "TESTING ALL STATOR WINDINGS TO GROUND" on the previous page.
6. Repeat Step 5 at Pin Location 3 (Wire 66A) and Stator Lead 33.
7. Repeat Step 5 at Pin Location 7 (Wire 6) and Stator Lead 33.

For the following steps (8 through 10) an additional large paper clip (or similar item) will be needed:

8. Insert a large paper clip into Pin Location 1 (Wire 77). Connect the red tester probe to the paper clip. Insert the additional large paper clip into Pin Location 3 (Wire 66A). Connect the black tester probe to this paper clip. Refer to Steps 5a through 5c of "TESTING ALL STATOR WINDINGS TO GROUND" on the previous page.
9. Insert a large paper clip into Pin Location 1 (Wire 77). Connect the red tester probe to the paper clip. Insert the additional large paper clip into Pin Location 7 (Wire 6). Connect the black tester probe to this paper clip. Refer to Steps 5a through 5c of "TESTING ALL STATOR WINDINGS TO GROUND" on the previous page.
10. Insert a large paper clip into Pin Location 3 (Wire 66A). Connect the red tester probe to the paper clip. Insert the additional large paper clip into Pin Location 7 (Wire 6). Connect the black tester probe to this paper clip. Refer to Steps 5a through 5c of "TESTING ALL STATOR WINDINGS TO GROUND" on the previous page.

ROTOR INSULATION RESISTANCE TEST

Before attempting to test rotor insulation, the brush holder must be completely removed. The rotor must be completely isolated from other components before starting the test. Attach all leads of all stator windings to ground.

1. Connect the red tester lead to the positive (+) slip ring (nearest the rotor bearing).
2. Connect the black tester probe to a clean frame ground, such as a clean metal part of the rotor shaft.
3. Turn the tester switch OFF.
4. Plug the tester into a 120 volts AC wall socket and set the voltage switch to "1500 volts".
5. Turn the tester switch "On" and make sure the pilot light has turned on.
6. Observe the breakdown lamp, then turn the tester switch OFF. DO NOT APPLY VOLTAGE LONGER THAN ONE (1) SECOND.

If the breakdown lamp came on during the one (1) second test, cleaning and drying of the rotor may be necessary. After cleaning and drying, repeat the insulation breakdown test. If breakdown lamp comes on during the second test, replace the rotor assembly.

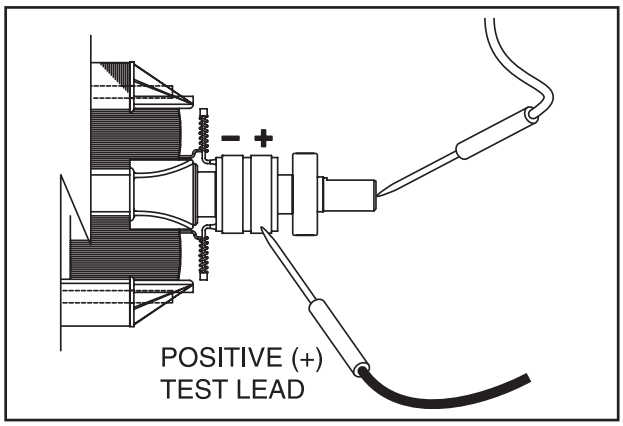


Figure 4. Testing Rotor Insulation

CLEANING THE GENERATOR

Caked or greasy dirt may be loosened with a soft brush or a damp cloth. A vacuum system may be used to clean up loosened dirt. Dust and dirt may also be removed using dry, low-pressure air (25 psi maximum).

CAUTION: DO NOT USE SPRAYED WATER TO CLEAN THE GENERATOR. SOME OF THE WATER WILL BE RETAINED ON GENERATOR WINDINGS AND TERMINALS, AND MAY CAUSE VERY SERIOUS PROBLEMS.

DRYING THE GENERATOR

To dry a generator, proceed as follows:

1. Open the generator main circuit breaker. NO ELECTRICAL LOADS MUST BE APPLIED TO THE GENERATOR WHILE DRYING.
2. Disconnect all Wires 4 from the voltage regulator.
3. Provide an external source to blow warm, dry air through the generator interior (around the rotor and stator windings. DO NOT EXCEED 185° F. (85° C.).
4. Start the generator and let it run for 2 or 3 hours.
5. Shut the generator down and repeat the stator and rotor insulation resistance tests.

GENERAL

Standby electric power generators will often run unattended for long periods of time. Such operating parameters as (a) engine oil pressure, (b) engine temperature, (c) engine operating speed, and (d) engine cranking and startup are not monitored by an operator during automatic operation. Because engine operation will not be monitored, the use of engine protective safety devices is required to prevent engine damage in the event of a problem.

Prepackaged generator engines mount several engine protective devices. These devices work in conjunction with a circuit board, to protect the engine against such operating faults as (a) low engine oil pressure, (b) high temperature, (c) overspeed, and (d) overcrank. On occurrence of any one or more of those operating faults, circuit board action will effect an engine shutdown.

LOW OIL PRESSURE SHUTDOWN:

See Figure 1. An oil pressure switch is mounted on the engine oil filter adapter. This switch has normally closed contacts that are held open by engine oil pressure during cranking and startup. Should oil pressure drop below approximately 10 psi, the switch contacts will close. On closure of the switch contacts, a Wire 86 circuit from the circuit board will be connected to ground. Circuit board action will then de-energize a "run relay" (on the circuit board). The run relay's normally open contacts will then open and a 12 volts DC power supply to a Wire 14 circuit will then be terminated. This will result in closure of a fuel shutoff solenoid and loss of engine ignition.

HIGH OIL TEMPERATURE SHUTDOWN:

An oil temperature switch (Figure 1) is mounted on the engine block. The thermal switch has normally open contacts that will close if oil temperature should exceed approximately 284° F (140° C). This will result in the same action as a low oil pressure shutdown.

OVERSPEED SHUTDOWN:

During engine cranking and operation, the circuit board receives AC voltage and frequency signals from the generator engine run windings, via Wire 66A. Should the AC frequency exceed approximately 72Hz (4320 rpm), circuit board action will de-energize a "run relay" (mounted on the circuit board). The relay's contacts will open, to terminate engine ignition and close a fuel shutoff solenoid. The engine will then shut down. This feature protects the engine-generator against damaging overspeeds.

NOTE: The circuit board also uses engine run winding output to terminate engine cranking at approximately 30 Hz (1800 rpm). In addition, the engine run winding output is used by the circuit board as an "engine running" signal The circuit board will not initiate transfer of electrical loads to the "Standby" source unless the engine is running at 30 Hz or above.

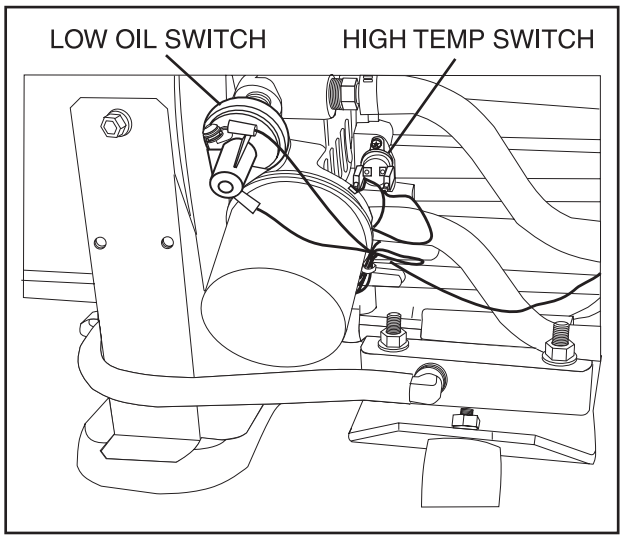


Figure 1. Engine Protective Switches on an Air-Cooled Engine

OVERCRANK SHUTDOWN:

Automatic engine cranking and startup normally occurs when the circuit board senses that utility source voltage has dropped below approximately 60 percent of its nominal rated voltage and remains at that low level longer than fifteen (15) seconds. At the end of fifteen (15) seconds, circuit board action will energize a crank relay and a run relay (both relays are on the circuit board). On closure of the crank relay contacts, circuit board action will deliver 12 volts DC to a starter contactor relay (SCR, for v-twin models) or a starter contactor (SC, for single cylinder models). The control contactor will energize and battery power will be delivered to the starter motor (SM). The engine will then crank.

During a manual startup (Auto-Off-Manual switch at MANUAL), action is the same as during an automatic start, except that cranking will begin immediately when the switch is set to MANUAL.

Circuit board action (during both a manual and an automatic start) will hold the crank relay energized for 15 seconds on. The relay will then de-energize for 15 seconds off. It will then energize for seven (7) seconds on and de-energize for seven (7) seconds off. It will repeat this same cycle for another 45 seconds.

If the engine has not started after approximately 90 seconds of these crank-rest cycles, cranking will automatically terminate and shutdown will occur. The circuit board uses AC signals from the stator engine run winding as an indication that the engine has started.

CONTROL PANEL

GENERAL:

See Figure 1. The front face of this panel mounts (a) an Auto-Off-Manual switch, (b) a 15 amp fuse, (c) a 7.5 amp fuse, (d) a set exercise switch and (e) the protection systems.

120 VAC GFCI OUTLET:

The generator is equipped with an external, 15 amp, 120 volt, GFCI convenience outlet that is located in the right rear of the generator enclosure. When the generator is running, in the absence of utility power, this outlet may be used to power items outside the home such as lights or power tools. This outlet may also be used when utility power is present by running the generator in manual mode. This oultlet does not provide power if the generator is not running. This outlet is protected by a 7.5 amp circuit breaker located in the generator control panel. (Figure 1).

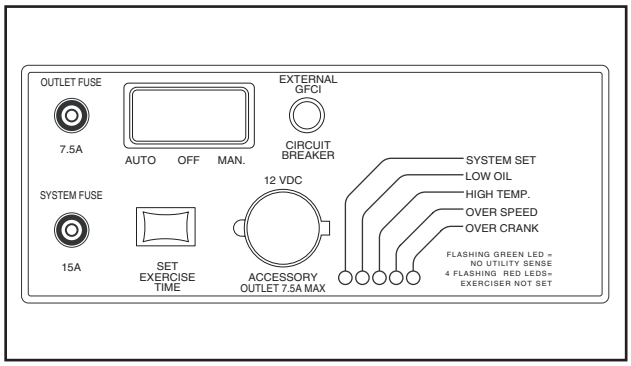


Figure 1. Control Panel

AUTO-OFF-MANUAL SWITCH:

Use this switch to (a) select fully automatic operation, (b) to crank and start the engine manually, and (c) to shut the unit down or to prevent automatic startup.

1. AUTO position:
   a. Select AUTO for fully automatic operation.
   b. When AUTO is selected, circuit board will monitor utility power source voltage.
   c. Should utility voltage drop below a preset level and remain at such a low level for a preset time, circuit board action will initiate engine cranking and startup.
   d. Following engine startup, circuit board action will initiate transfer of electrical loads to the "Standby" source side.
   e. On restoration of utility source voltage above a preset level, circuit board action will initiate retransfer back to the "Utility Source" side.
   f. Following retransfer, circuit board will shut the engine down and will then continue to monitor utility source voltage.
2. OFF Position:
   a. Set the switch to OFF to stop an operating engine.
   b. To prevent an automatic startup from occurring, set the switch to OFF.
3. MANUAL Position:
   a. Set switch to MANUAL to crank and start unit manually.
   b. Engine will crank cyclically and start (same as automatic startup, but without transfer). The unit will transfer if utility voltage is not available.

DANGER: WHEN THE GENERATOR IS INSTALLED IN CONJUNCTION WITH AN AUTOMATIC TRANSFER SWITCH, ENGINE CRANKING AND STARTUP CAN OCCUR AT ANY TIME WITHOUT WARNING (PROVIDING THE AUTO-OFF-MANUAL SWITCH IS SET TO AUTO). TO PREVENT AUTOMATIC STARTUP AND POSSIBLE INJURY THAT MIGHT BE CAUSED BY SUCH STARTUP, ALWAYS SET THE AUTO-OFF-MANUAL SWITCH TO ITS OFF POSITION BEFORE WORKING ON OR AROUND THIS EQUIPMENT.

15 AMP FUSE:

This fuse protects the DC control circuit (including the circuit board) against overload. If the fuse element has melted open due to an overload, engine cranking or running will not be possible. Should fuse replacement become necessary, use only an identical 15 amp replacement fuse.

7.5 AMP FUSE:

This fuse protects the 12 VDC accessory socket against overload. If the fuse element has melted open due to an overload, the 12 VDC socket will not provide power to accessories. Should fuse replacement become necessary, use only an identical 7.5 amp replacement fuse.

THE SET EXERCISE SWITCH:

The air-cooled, prepackaged automatic standby generator will start and exercise once every seven (7) days, on a day and at a time of day selected by the owner or operator. The set exercise time switch is provided to select the day and time of day for system exercise.

See Section 5 ("The 7-Day Exercise Cycle") for instructions on how to set exercise time.

DANGER: THE GENERATOR WILL CRANK AND START WHEN THE SET EXERCISE TIME SWITCH IS SET TO "ON". DO NOT ACTUATE THE SWITCH TO "ON" UNTIL AFTER YOU HAVE READ THE INSTRUCTIONS IN PART 5.

PROTECTION SYSTEMS:

Unlike an automobile engine, the generator may have to run for long periods of time with no operator present to monitor engine conditions. For that reason, the engine is equipped with the following systems that protect it against potentially damaging conditions:

- Low Oil Pressure Sensor
- High Temperature Sensor
- Overcrank
- Overspeed

There are LED readouts on the control panel to notify you that one of these faults has occurred. There is also a “System Set” LED that is lit when all of the following conditions are true:

1. The Auto-Off-Manual switch is set to the AUTO position.
2. The NOT IN AUTO dip switch is set to the OFF position on the control board.
3. No alarms are present.

TO SELECT AUTOMATIC OPERATION

The following procedure applies only to those installations in which the air-cooled, prepackaged automatic standby generator is installed in conjunction with a prepackaged transfer switch. Prepackaged transfer switches do not have an intelligence circuit of their own. Automatic operation on prepackaged transfer switch and generator combinations is controlled by circuit board action.

To select automatic operation when a prepackaged transfer switch is installed along with a prepackaged home standby generator, proceed as follows:

1. Check that the prepackaged transfer switch main contacts are at their UTILITY position, i.e., the load is connected to the utility power supply. If necessary, manually actuate the switch main contacts to their UTILITY source side. See Part 5 of this manual, as appropriate, for instructions.
2. Check that utility source voltage is available to transfer switch terminal lugs N1 and N2 (2-pole, 1-phase transfer switches).
3. Set the generator Auto-Off-Manual switch to its AUTO position.
4. Actuate the generator main line circuit breaker to its "On" or "Closed" position. With the preceding Steps 1 through 4 completed, a dropout in utility supply voltage below a preset level will result in automatic generator cranking and start-up. Following startup, the prepackaged transfer switch will be actuated to its "Standby" source side, i.e., loads powered by the standby generator.

MANUAL TRANSFER TO "STANDBY" AND MANUAL STARTUP

To transfer electrical loads to the "Standby" (generator) source and start the generator manually, proceed as follows:

1. On the generator panel, set the Auto-Off-Manual switch to OFF.
2. On the generator, set the main line circuit breaker to it's OFF or "Open" position.
3. Turn OFF the utility power supply to the transfer switch, using whatever means provided (such as a utility source line circuit breaker).
4. Manually actuate the transfer switch main contacts to their “Standby” position, i.e., loads connected to the “Standby” power source side.

NOTE: For instructions on manual operation of prepackaged transfer switches, see Part 5.

5. On the generator panel, set the Auto-Off-Manual switch to MANUAL. The engine should crank and start.
6. Let the engine warm up and stabilize for a minute or two at no-load.
7. Set the generator main line circuit breaker to its "On" or "Closed" position. The generator now powers the electrical loads.

MANUAL SHUTDOWN AND RETRANSFER BACK TO "UTILITY"

To shut the generator down and retransfer electrical loads back to the UTILITY position, proceed as follows:

1. Set the generator main line circuit breaker to its OFF or "Open" position.
2. Let the generator run at no-load for a few minutes, to cool.
3. Set the generator Auto-Off-Manual switch to OFF. Wait for the engine to come to a complete stop.
4. Turn off the utility power supply to the transfer switch using whatever means provided (such as a utility source main line circuit breaker)
5. Manually actuate the prepackaged transfer switch to its UTILITY source side, i.e., load connected to the utility source.
6. Turn on the utility power supply to the transfer switch, using whatever means provided.
7. Set the generator Auto-Off-Manual switch to AUTO.

INTRODUCTION

When the prepackaged generator is installed in conjunction with a prepackaged transfer switch, either manual or automatic operation is possible. Manual transfer and engine startup, as well as manual shutdown and retransfer are covered in Section 1.6. Selection of fully automatic operation is also discussed in that section. This section will provide a step-by-step description of the sequence of events that will occur during automatic operation of the system.

AUTOMATIC OPERATING SEQUENCES

PHASE 1 - UTILITY VOLTAGE AVAILABLE:

With utility source voltage available to the transfer switch, that source voltage is sensed by a circuit board in the generator panel and the circuit board takes no action.

Electrical loads are powered by the utility source and the Auto-Off-Manual switch is set to AUTO.

PHASE 2- UTILITY VOLTAGE DROPOUT:

If a dropout in utility source voltage should occur below about 60 percent of the nominal utility source voltage, a 15 second timer on the circuit board will start timing. This timer is required to prevent false generator starts that might be caused by transient utility voltage dips.

PHASE 3- ENGINE CRANKING:

When the circuit board's 15 second timer has finished timing and if utility source voltage is still below 60 percent of the nominal source voltage, circuit board action will energize a crank relay and a run relay. Both of these relays are mounted on the circuit board.

If the engine starts, cranking will terminate when generator AC output frequency reaches approximately 30 Hz.

PHASE 4-ENGINE STARTUP AND RUNNING:

The circuit board senses that the engine is running by receiving a voltage/frequency signal from the engine run windings.

When generator AC frequency reaches approximately 30 Hz, an engine warm-up timer on the circuit board turns on. That timer will run for about ten (10) seconds.

The engine warm-up timer lets the engine warm-up and stabilize before transfer to the "Standby" source can occur.

NOTE: The engine can be shut down manually at any time, by setting the Auto-Off-Manual switch to OFF.

PHASE 5- TRANSFER TO "STANDBY":

When the circuit board's engine warm-up timer has timed out and AC voltage has reached 50 percent of the nominal rated voltage, circuit board action completes a transfer relay circuit to ground. The transfer relay is housed in the prepackaged transfer switch enclosure.

The transfer relay energizes and transfer of loads to the "Standby" power source occurs. Loads are now powered by standby generator AC output.

PHASE 6- "UTILITY" POWER RESTORED:

When utility source voltage is restored above about 80 percent of the nominal supply voltage, a 15 second timer on the circuit board starts timing. If utility voltage remains sufficiently high at the end of 15 seconds, retransfer can occur.

PHASE 7- RETRANSFER BACK TO "UTILITY":

At the end of the 15 second delay, circuit board action will open a circuit to a transfer relay (housed in the transfer switch). The transfer relay will then de-energize and retransfer back to the utility source will occur. Loads are now powered by utility source power. On retransfer, an engine cool-down timer starts timing and will run for about one (1) minute.

PHASE 8- GENERATOR SHUTDOWN:

When the engine cool-down timer has finished timing, and if the minimum run timer has timed out, engine shutdown will occur.

AUTOMATIC OPERATING SEQUENCES CHART

SEQ.	CONDITION	ACTION	SENSOR, TIMER OR OTHER
1	Utility source voltage is available.	No action	Voltage Dropout Sensor on circuit circuit board.
2	Utility voltage dropout below 60% of rated voltage occurs.	A 15-second timer on circuit board turns on.	Voltage Dropout Sensor and 15 second timer on circuit board.
3	Utility voltage is still below 60% of rated voltage.	15-second timer runs for 15 seconds, then stops.	Voltage Dropout Sensor and 15 second timer.
4	Utility voltage is still low after 15 seconds.	Circuit board action energizes a crank relay and a run relay. See NOTE 1.	Circuit board crank and run relays.
5	Utility voltage still low and the engine has started.	Circuit board's "engine warmup timer" runs for 10 seconds.	Engine Warmup Timer (10 seconds)
6	Engine running and "engine warmup timer" times out. AC output voltage above 50% nominal voltage.	Circuit board action energizes a transfer relay in transfer switch and transfer to "Standby" occurs.	Circuit board transfer relay circuit Transfer switch transfer relay.
7	Engine running and load is powered by Standby power.	No further action	Circuit board voltage pickup sensor continues to seek an acceptable "Utility" voltage.
8	Utility source voltage is restored above 80% of rated	Circuit board "voltage pickup sensor" reacts and a "re-transfer time delay" turns on.	Voltage Pickup Sensor (80%) Return to Utility Timer (15 seconds)
9	Utility voltage still high after 15 seconds.	"Return to Utility Timer" times out	Return to Utility Timer
10	Utility voltage still high.	Circuit board action opens the transfer relay circuit to ground. Transfer relay de-energizes and retransfer to "Utility" occurs.	Circuit board transfer relay circuit Transfer switch transfer relay.
11	Engine still running, loads are powered by Utility source.	Circuit board "engine cool down timer" starts running.	Circuit board Engine Cool down Timer (1 minute)
12		After 1 minute, "engine cool down timer" stops and circuit board's run relay de-energizes. Engine shuts down.	Engine Cool down Timer Circuit board Run Relay.
13	Engine is shut down, loads are powered by "Utility" source. Return to Sequence 1.	No action.	Voltage Dropout Sensor on circuit circuit board.

PART 2

AC GENERATORS

Air-cooled, Prepackaged Automatic Standby Generators

Models:
6 kW NG, 7 kW LP
12 kW NG, 12 kW LP
13 kW NG, 15 kW LP

TABLE OF CONTENTS

PART	TITLE
2.1	Description and Components
2.2	Operational Analysis
2.3	Troubleshooting Flow Charts
2.4	Diagnostic Tests

INTRODUCTION

The air-cooled, pre-packaged automatic standby system is an easy to install, fully enclosed and self-sufficient electric power system. It is designed especially for homeowners, but may be used in other applications as well. On occurrence of a utility power failure, this high performance system will (a) crank and start automatically, and (b) automatically transfer electrical loads to generator AC output.

The generator revolving field (rotor) is driven by an air-cooled engine at about 3600 rpm.

The generator may be used to supply electrical power for the operation of 120 and/or 240 volts, 1phase, 60 Hz, AC loads.

A 2-pole, "V-Type", prepackaged transfer switch is shipped with the unit (see Part 3). Prepackaged transfer switches do not include an "intelligence circuit" of their own. Instead, automatic startup, transfer, running, retransfer and shutdown operations are controlled by a solid state circuit board in the generator control panel.

ENGINE-GENERATOR DRIVE SYSTEM

The generator revolving field is driven by an air-cooled, horizontal crankshaft engine. The generator is directly coupled to the engine crankshaft (see Figure 1), and mounted in an enclosure. Both the engine and generator rotor are driven at approximately 3600 rpm, to provide a 60 Hz AC output.

THE AC GENERATOR

Figure 1 shows the major components of the AC generator.

ROTOR ASSEMBLY

The 2-pole rotor must be operated at 3600 rpm to supply a 60 Hertz AC frequency. The term "2-pole" means the rotor has a single north magnetic pole and a single south magnetic pole. As the rotor rotates, its lines of magnetic flux cut across the stator assembly windings and a voltage is induced into the stator windings. The rotor shaft mounts a positive (+) and a negative (-) slip ring, with the positive (+) slip ring nearest the rear bearing carrier. The rotor bearing is pressed onto the end of the rotor shaft. The tapered rotor shaft is mounted to a tapered crankshaft and is held in place with a single through bolt.

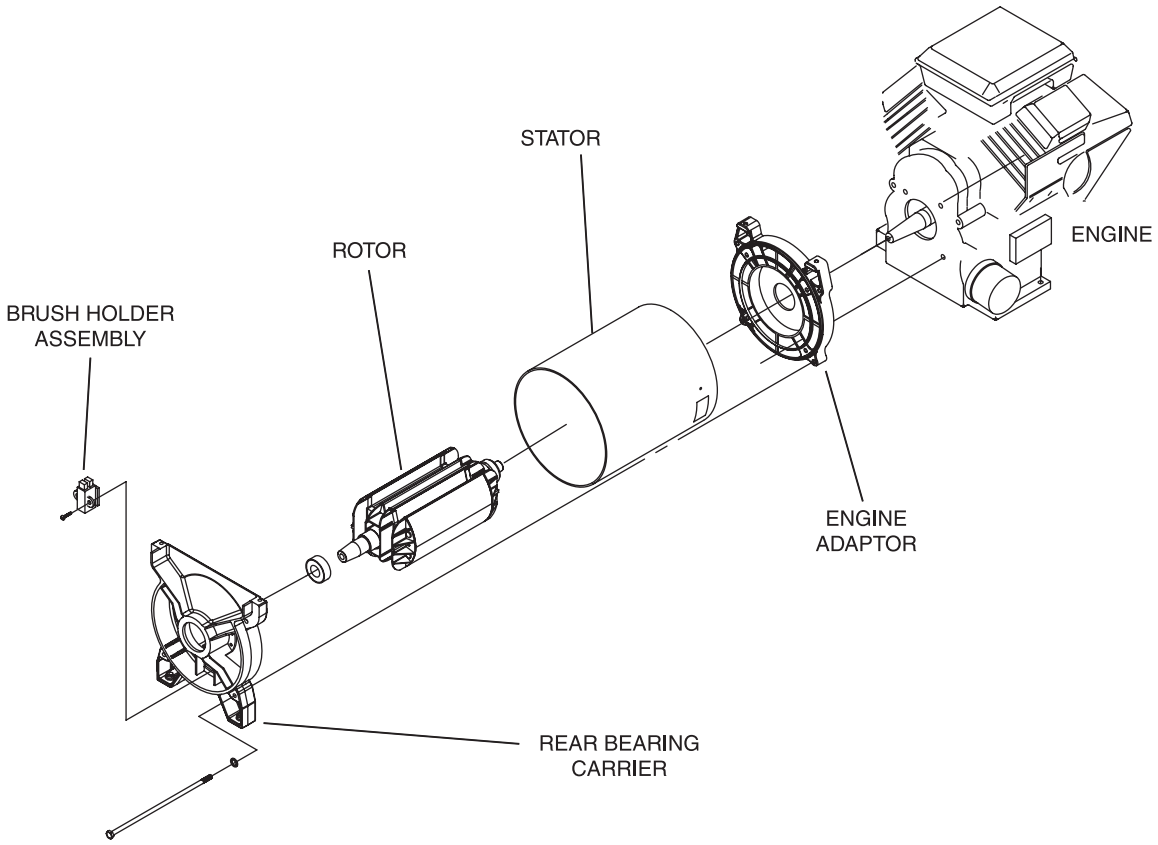


Figure 1. AC Generator Exploded View

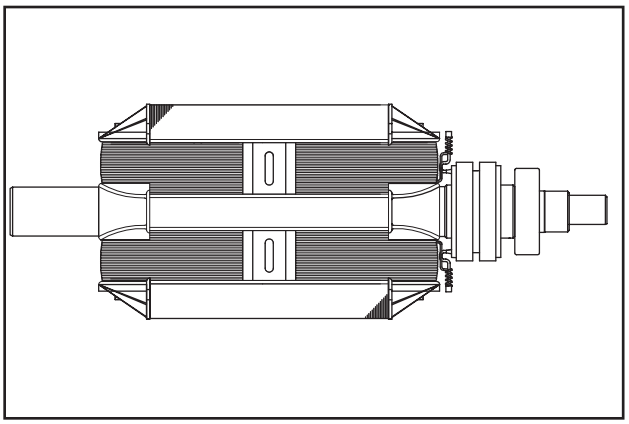


Figure 2. The 2-Pole Rotor Assembly

STATOR ASSEMBLY

The stator can houses and retains (a) dual AC power windings, (b) excitation winding, (c) battery charge winding and (d) engine run winding. A total of twelve (12) stator leads are brought out of the stator can as shown in Figure 3.

The stator can is sandwiched between an engine adapter and a rear bearing carrier. It is retained in that position by four stator studs.

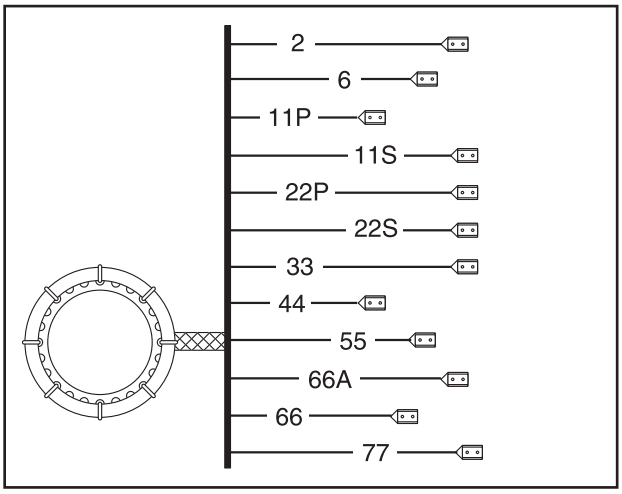


Figure 3 Stator Assembly Leads

BRUSH HOLDER AND BRUSHES

The brush holder is retained to the rear bearing carrier by means of two #10-32 x 9/16 Taptite screws. A positive (+) and a negative (-) brush are retained in the brush holder, with the positive (+) brush riding on the slip ring nearest the rotor bearing.

Wire 4 connects to the positive (+) brush and Wire 0 to the negative (-) brush. Wire 0 connects to frame ground. Rectified and regulated excitation current, as well as current from a field boost circuit, are delivered to the rotor windings via Wire 4, and the positive (+) brush and slip ring. The excitation and field boost current passes through the windings and to frame ground via the negative (-) slip ring and brush, and Wire 0. This current flow creates a magnetic field around the rotor having a flux concentration that is proportional to the amount of current flow.

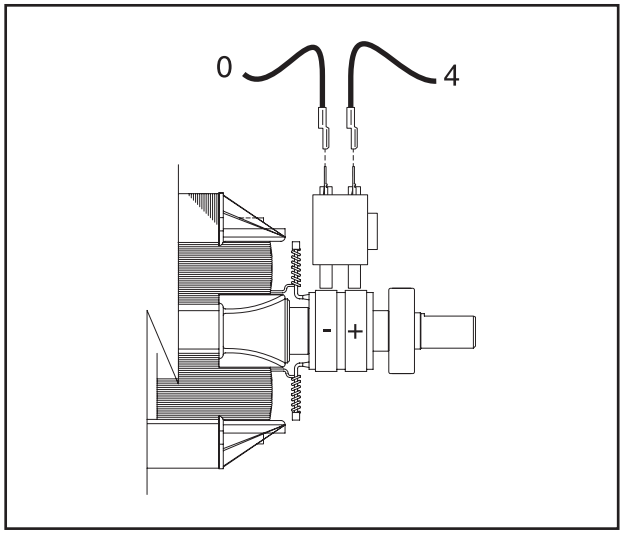


Figure 4. Brush Holder and Brushes

OTHER AC GENERATOR COMPONENTS

Some AC generator components are housed in the generator control panel enclosure, and are not shown in Figure 1. These are (a) an excitation circuit breaker, (b) a voltage regulator, and (c) a main line circuit breaker.

EXCITATION CIRCUIT BREAKER:

The excitation circuit breaker (CB2) is housed in the generator panel enclosure and electrically connected in series with the excitation (DPE) winding output to the voltage regulator. The breaker is self-resetting, i.e.; its contacts will close again when excitation current drops to a safe value.

If the circuit breaker has failed open, excitation current flow to the voltage regulator and, subsequently, to the rotor windings will be lost. Without excitation current flow, AC voltage induced into the stator AC power windings will drop to a value that is commensurate with the rotor residual magnetism (see Figure 5).

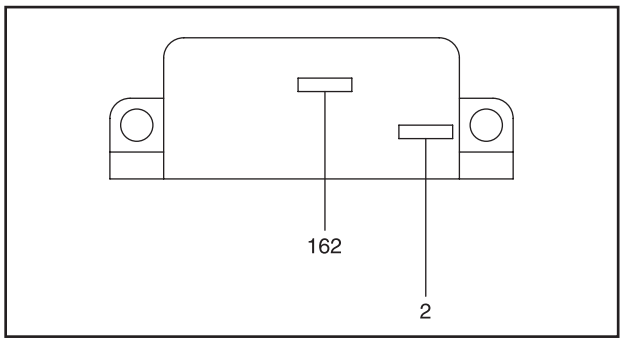


Figure 5. Excitation Circuit Breaker

VOLTAGE REGULATOR:

A typical voltage regulator is shown in Figure 6. Unregulated AC output from the stator excitation winding is delivered to the regulator's DPE terminals, via Wire 2, the excitation circuit breaker, Wire 162, and Wire 6. The voltage regulator rectifies that current and, based on stator AC power winding sensing, regulates it. The rectified and regulated excitation current is then delivered to the rotor windings from the positive (+) and negative (-) regulator terminals, via Wire 4 and Wire 1. Stator AC power winding “sensing” is delivered to the regulator "SEN" terminals via Wires 11 and 22.

The regulator provides "over-voltage" protection, but does not protect against "under-voltage". On occurrence of an "over-voltage' condition, the regulator will "shut down" and complete loss Of excitation current to the rotor will occur. Without excitation current, the generator AC output voltage will drop to approximately one-half (or lower) of the unit's rated voltage.

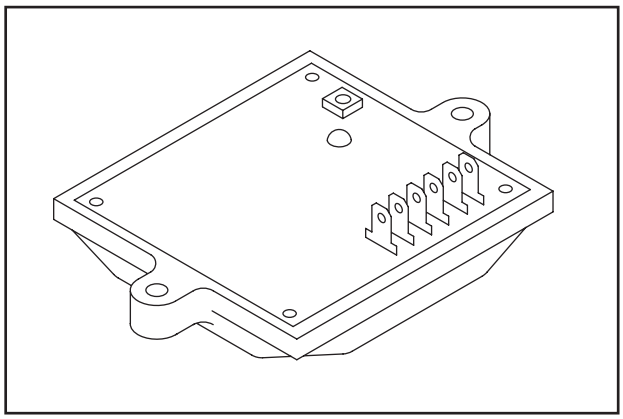


Figure 6. Typical Voltage Regulator

A single red lamp (LED) glows during normal operation. The lamp will become dim if excitation winding AC output diminishes. It will go out on occurrence of an open condition in the sensing AC output circuit.

An adjustment potentiometer permits the stator AC power winding voltage to be adjusted. Perform this adjustment with the generator running at no-load, and with a 62 Hz AC frequency (62 Hz equals 3720 rpm). At the stated no-load frequency, adjust to obtain a line-to-line AC voltage of about 252 volts.

MAIN LINE CIRCUIT BREAKER:

The main line circuit breaker protects the generator against electrical overload. See “Specifications” on inside front cover of this manual for amp ratings.

ROTOR RESIDUAL MAGNETISM

The generator revolving field (rotor) may be considered to be a permanent magnet. Some 'residual" magnetism is always present in the rotor. This residual magnetism is sufficient to induce a voltage into the stator AC power windings that is approximately 2-12 volts AC.

FIELD BOOST

FIELD BOOST CIRCUIT:

When the engine is cranking, direct current flow is delivered from a circuit board to the generator rotor windings, via Wire 4.

The field boost system is shown schematically in Figure 2. Manual and automatic engine cranking is initiated by circuit board action, when that circuit board energizes a crank relay (K1). Battery voltage is then delivered to field boost Wire 4 (and to the rotor), via a field boost resistor and diode. The crank relay, field boost resistor and diode are all located on the circuit board.

Notice that field boost current is available only while the crank relay (K1) is energized, i.e., while the engine is cranking.

Field boost voltage is reduced from that of battery voltage by the resistor action and, when read with a DC voltmeter, will be approximately 9 or 10 volts DC.

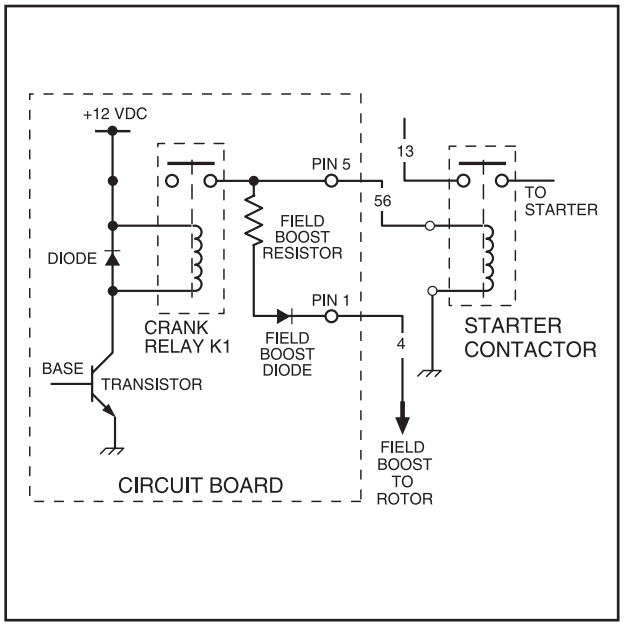


Figure 2. Field Boost Circuit Schematic

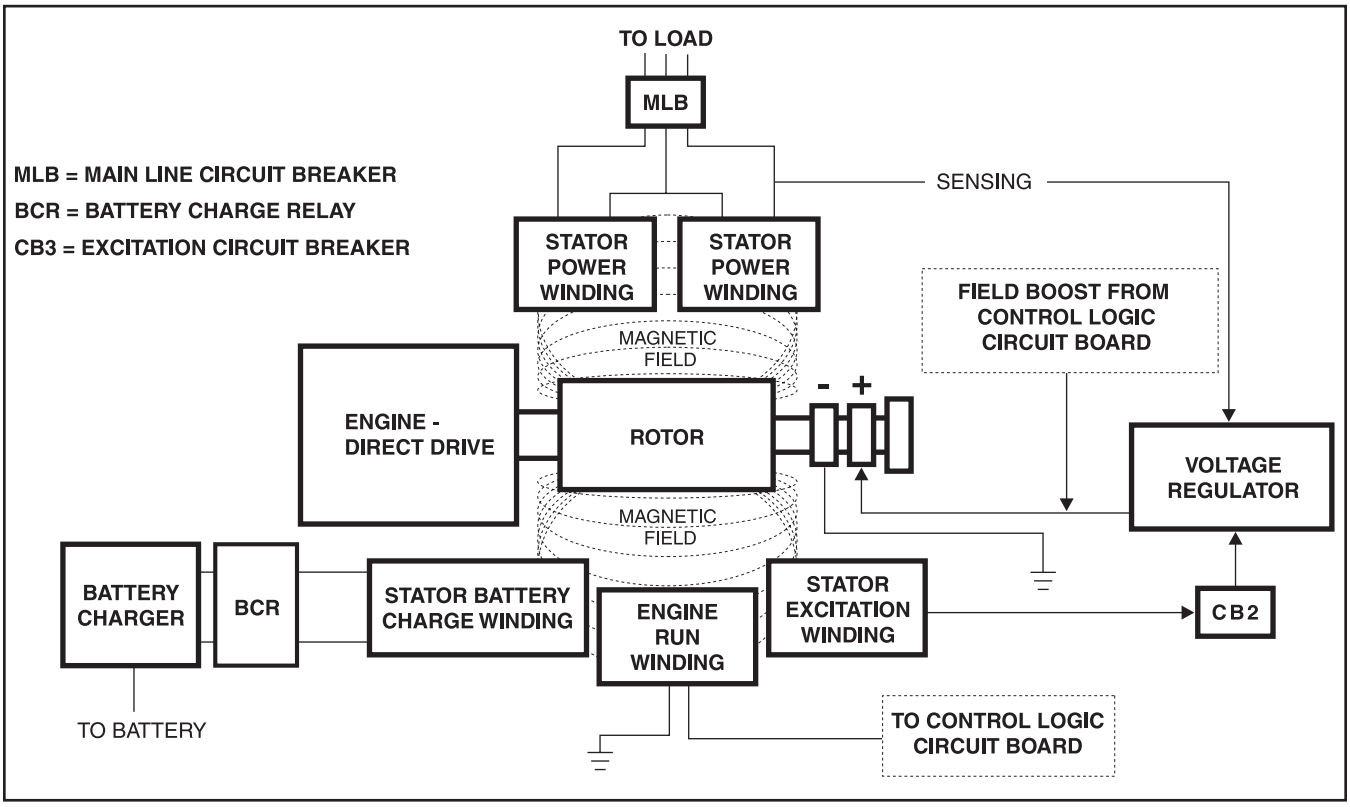


Figure 1. Operating Diagram of AC Generator

OPERATION

STARTUP:

When the engine is started, residual plus field boost magnetism from the rotor induces a voltage into (a) the stator AC power windings, (b) the stator excitation or DPE windings, (c) the stator battery charge, and (d) engine run winding. In an "on-speed" condition, residual plus field boost magnetism are capable of creating approximately one-half the unit's rated voltage.

ON-SPEED OPERATION:

As the engine accelerates, the voltage that is induced into the stator windings increases rapidly, due to the increasing speed at which the rotor operates.

FIELD EXCITATION:

An AC voltage is induced into the stator excitation (DPE) windings. The DPE winding circuit is completed to the voltage regulator, via Wire 2, excitation circuit breaker, Wire 162, and Wire 6. Unregulated alternating current can flow from the winding to the regulator.

The voltage regulator "senses" AC power winding output voltage and frequency via stator Wires 11 and 22.

The regulator changes the AC from the excitation winding to DC. In addition, based on the Wires 11 and 22 sensing signals, it regulates the flow of direct current to the rotor.

The rectified and regulated current flow from the regulator is delivered to the rotor windings, via Wire 4, and the positive brush and slip ring. This excitation current flows through the rotor windings and is directed to ground through the negative (-) slip ring and brush, and Wire 0.

The greater the current flow through the rotor windings, the more concentrated the lines of flux around the rotor become.

The more concentrated the lines of flux around the rotor that cut across the stationary stator windings, the greater the voltage that is induced into the stator windings.

Initially, the AC power winding voltage sensed by the regulator is low. The regulator reacts by increasing the flow of excitation current to the rotor until voltage increases to a desired level. The regulator then maintains the desired voltage. For example, if voltage exceeds the desired level, the regulator will decrease the flow of excitation current. Conversely, if voltage drops below the desired level, the regulator responds by increasing the flow of excitation current.

AC POWER WINDING OUTPUT:

A regulated voltage is induced into the stator AC power windings. When electrical loads are connected across the AC power windings to complete the circuit, current can flow in the circuit. The regulated AC power winding output voltage will be in direct proportion to the AC frequency. For example, on units rated 120/240 volts at 60 Hz, the regulator will try to maintain 240 volts (line-to-line) at 60 Hz. This type of regulation system provides greatly improved motor starting capability over other types of systems.

BATTERY CHARGE WINDING OUTPUT:

A voltage is induced into the battery charge windings. Output from these windings is delivered to a battery charger, via Wires 66 and 77. The resulting direct current from the battery charger is delivered to the unit battery, via Wire 15, a 15 amp fuse, and Wire 13. This output is used to maintain battery state of charge during operation.

ENGINE RUN WINDING OUTPUT:

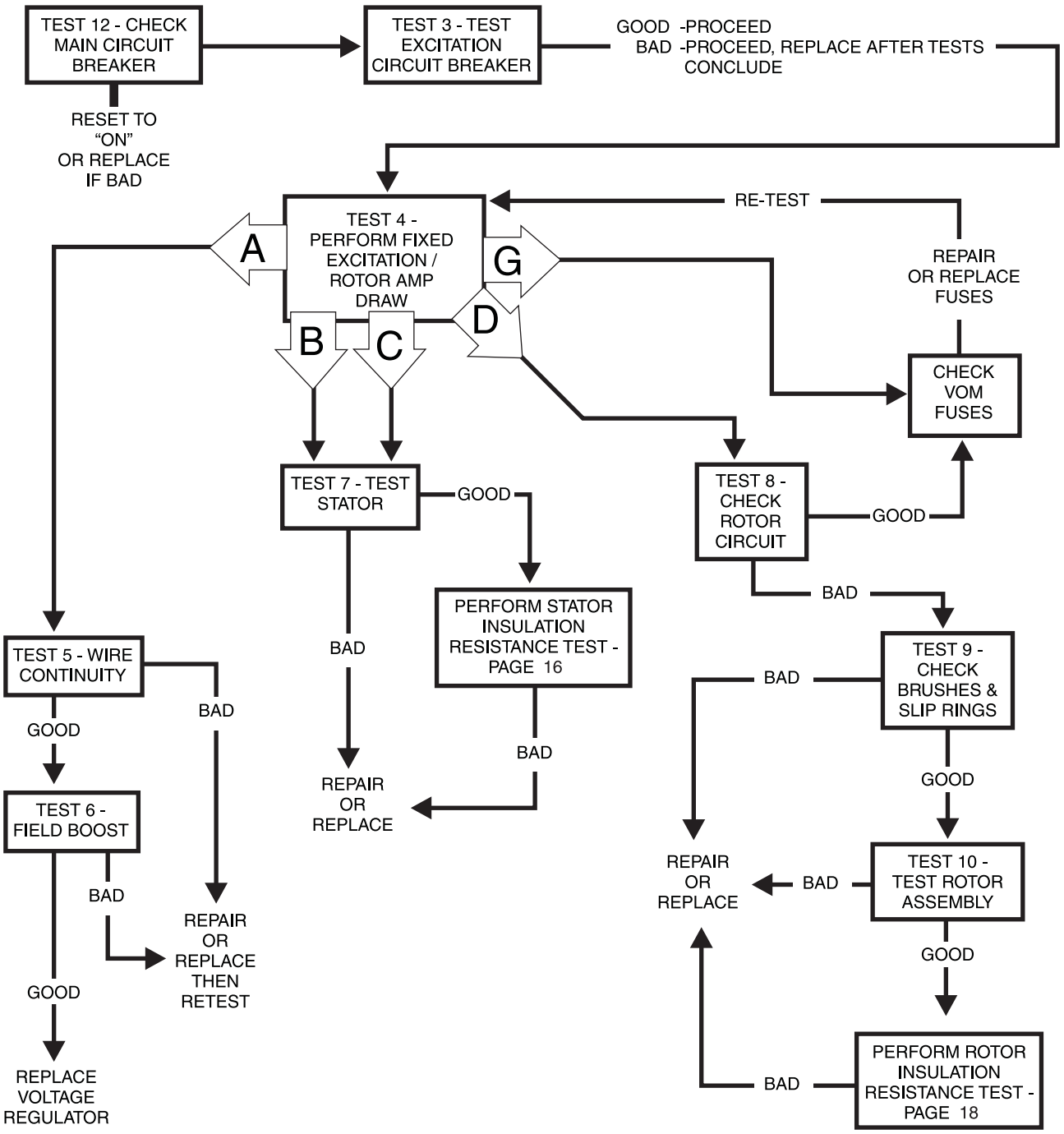
A voltage is induced into the engine run winding and delivered to a solid state circuit board , via Wire 66A. This output "tells" the circuit board that the engine has started and what its operating speed is. The circuit board uses these signals from the engine run winding to (a) terminate cranking, and (b) turn on various timing circuits that control automatic operation. See Part 4, "DC Control".

GENERAL

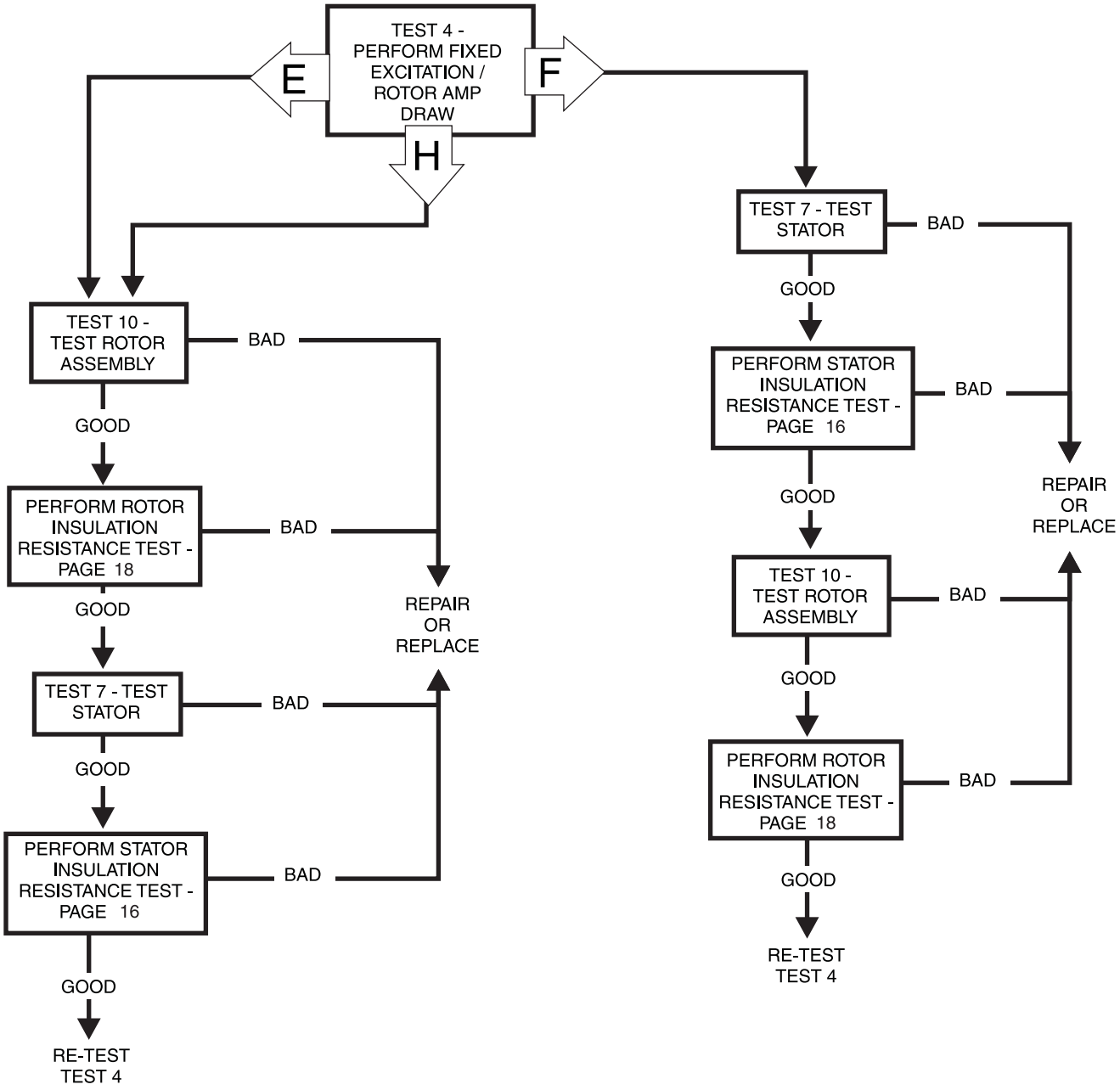
Use the “Flow Charts” in conjunction with the detailed instructions in Section 2.4. Test numbers used in the flow charts correspond to the numbered tests in Section 2.4.

The first step in using the flow charts is to correctly identify the problem. Once that has been done, locate the problem on the following pages. For best results, perform all tests in the exact sequence shown in the flow charts.

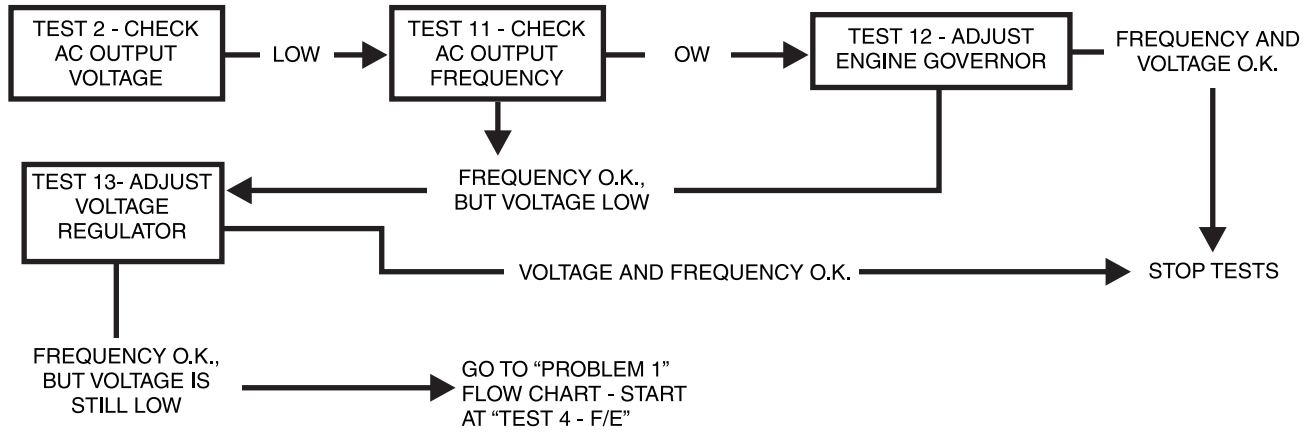
Problem 1 - Generator Produces Zero Voltage or Residual Voltage



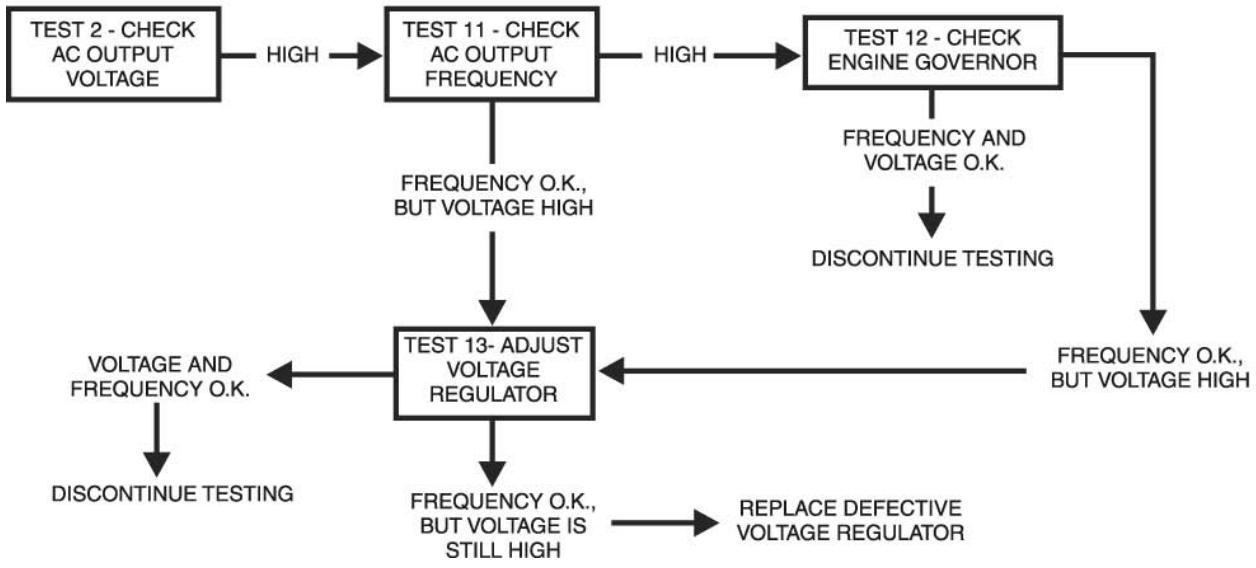
Problem 1 - Generator Produces Zero Voltage or Residual Voltage (Continued)



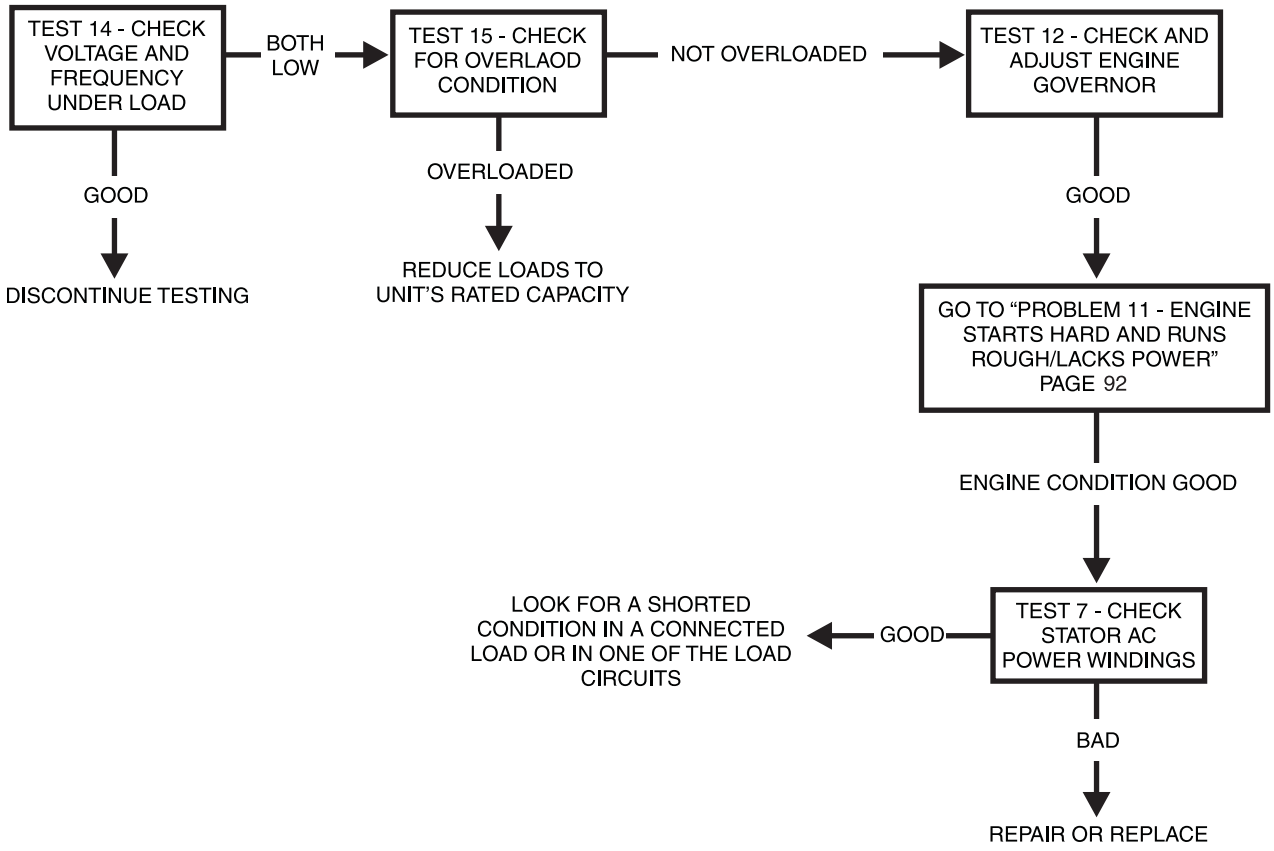
Problem 2 - Generator Produces Low Voltage at No-Load


TEST 2 - CHECK AC OUTPUT VOLTAGE
LOW
TEST 11 - CHECK AC OUTPUT FREQUENCY
OW
TEST 12 - ADJUST ENGINE GOVERNOR
FREQUENCY AND VOLTAGE O.K.
FREQUENCY O.K., BUT VOLTAGE LOW
TEST 13- ADJUST VOLTAGE REGULATOR
VOLTAGE AND FREQUENCY O.K.
STOP TESTS
FREQUENCY O.K., BUT VOLTAGE IS STILL LOW
GO TO "PROBLEM 1" FLOW CHART - START AT "TEST 4 - F/E"

Problem 3 - Generator Produces High Voltage at No-Load


TEST 2 - CHECK AC OUTPUT VOLTAGE
HIGH
TEST 11 - CHECK AC OUTPUT FREQUENCY
HIGH
TEST 12 - CHECK ENGINE GOVERNOR
FREQUENCY AND VOLTAGE O.K.
DISCONTINUE TESTING
FREQUENCY O.K., BUT VOLTAGE HIGH
TEST 13- ADJUST VOLTAGE REGULATOR
FREQUENCY O.K., BUT VOLTAGE HIGH
VOLTAGE AND FREQUENCY O.K.
DISCONTINUE TESTING
FREQUENCY O.K., BUT VOLTAGE IS STILL HIGH
REPLACE DEFECTIVE VOLTAGE REGULATOR

Problem 4 - Voltage and Frequency Drop Excessively When Loads Are Applied


TEST 14 - CHECK VOLTAGE AND FREQUENCY UNDER LOAD
BOTH LOW
TEST 15 - CHECK FOR OVERLAOD CONDITION
NOT OVERLOADED
TEST 12 - CHECK AND ADJUST ENGINE GOVERNOR
GOOD
DISCONTINUE TESTING
OVERLOADED
REDUCE LOADS TO UNIT'S RATED CAPACITY
GOOD
GO TO "PROBLEM 11 - ENGINE STARTS HARD AND RUNS ROUGH/LACKS POWER" PAGE 92
ENGINE CONDITION GOOD
TEST 7 - CHECK STATOR AC POWER WINDINGS
GOOD
LOOK FOR A SHORTED CONDITION IN A CONNECTED LOAD OR IN ONE OF THE LOAD CIRCUITS
BAD
REPAIR OR REPLACE

INTRODUCTION

This section is provided to familiarize the service technician with acceptable procedures for the testing and evaluation of various problems that could be encountered on prepackaged standby generators with air-cooled engine. Use this section of the manual in conjunction with Section 2.3, "Troubleshooting Flow Charts". The numbered tests in this section correspond with those of Section 2.3.

Test procedures in this section do not require the use of specialized test equipment, meters or tools. Most tests can be performed with an inexpensive volt-ohm-milliammeter (VOM). An AC frequency meter is required, where frequency readings must be taken. A clamp-on ammeter may be used to measure AC loads on the generator.

Testing and troubleshooting methods covered in this section are not exhaustive. We have not attempted to discuss, evaluate and advise the home standby service trade of all conceivable ways in which service and trouble diagnosis might be performed. We have not undertaken any such broad evaluation. Accordingly, anyone who uses a test method not recommended herein must first satisfy himself that the procedure or method he has selected will jeopardize neither his nor the product's safety.

SAFETY

Service personnel who work on this equipment must be made aware of the dangers of such equipment. Extremely high and dangerous voltages are present that can kill or cause serious injury. Gaseous fuels are highly explosive and can be ignited by the slightest spark. Engine exhaust gases contain deadly carbon monoxide gas that can cause unconsciousness or even death. Contact with moving parts can cause serious injury. The list of hazards is seemingly endless.

When working on this equipment, use common sense and remain alert at all times. Never work on this equipment while you are physically or mentally fatigued. If you don't understand a component, device or system, do not work on it.

TEST 1- CHECK MAIN CIRCUIT BREAKER

DISCUSSION:

Often the most obvious cause of a problem is overlooked. If the generator main line circuit breaker is set to OFF or "Open", no electrical power will be supplied to electrical loads. If loads are not receiving power, perhaps the main circuit breaker is open or has failed.

PROCEDURE:

The generator main circuit breaker is located on the control panel. If loads are not receiving power, make sure the breaker is set to "On" or "Closed".

If you suspect the breaker may have failed, it can be tested as follows (see Figure 1):

1. Set a volt-ohm-milliammeter (VOM) to its "R x 1" scale and zero the meter.
2. With the generator shut down, disconnect all wires from the main circuit breaker terminals, to prevent interaction.
3. With the generator shut down, connect one VOM test probe to the Wire 11 terminal of the breaker and the other test probe to the Wire E1 terminal.
4. Set the breaker to its "On" or "Closed" position. The VOM should read CONTINUITY.
5. Set the breaker to its OFF or "Open" position and the VOM should indicate INFINITY.
6. Repeat Steps 4 and 5 with the VOM test probes connected across the breaker's Wire 44 terminal and the E2 terminal.

RESULTS:

1. If the circuit breaker tests good, go on to Test 2.
2. If the breaker tests bad, it should be replaced.

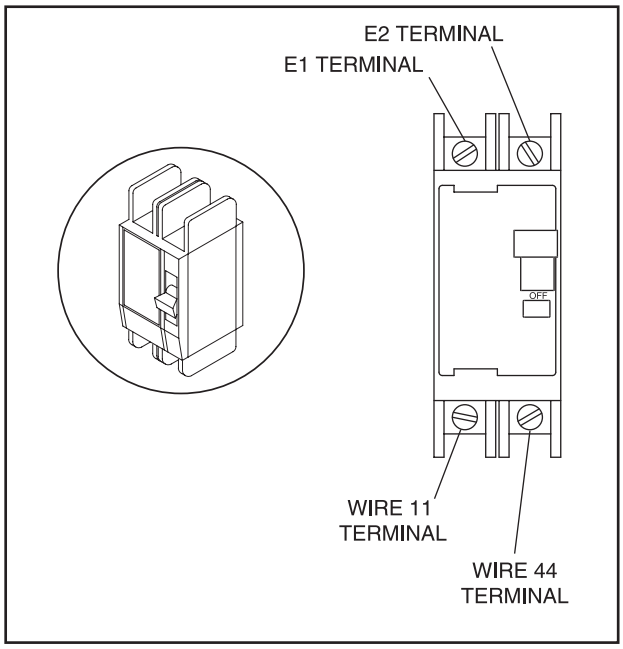


Figure 1. Generator Main Circuit Breaker Test Points

TEST 2- CHECK AC OUTPUT VOLTAGE

DISCUSSION:

A volt-ohm-milliammeter (VOM) may be used to check the generator output voltage. Output voltage may be checked at the unit's main circuit breaker terminals. Refer to the unit's DATA PLATE for rated line-to-line and line-to-neutral voltages.

DANGER: USE EXTREME CAUTION DURING THIS TEST. THE GENERATOR WILL BE RUNNING. HIGH AND DANGEROUS VOLTAGES WILL BE PRESENT AT THE TEST TERMINALS. CONNECT METER TEST CLAMPS TO THE HIGH VOLTAGE TERMINALS WHILE THE GENERATOR IS SHUT DOWN. STAY CLEAR OF POWER TERMINALS DURING THE TEST. MAKE SURE METER CLAMPS ARE SECURELY ATTACHED AND WILL NOT SHAKE LOOSE.

PROCEDURE:

1. With the engine shut down, connect the AC voltmeter test leads across the Wires 11 and 44 terminals of the generator main circuit breaker (see Figure 1). These connections will permit line-to-line voltages to be read.
2. Set the generator main circuit breaker to its OFF or "Open" position. This test will be conducted with the generator running at no-load.
3. Start the generator, let it stabilize and warm up for a minute or two.
4. Take the meter reading. On unit's having a rated line-to-line voltage of 240 volts, the no-load voltage should be about 242-252 volts AC.
5. Shut the engine down and remove the meter test leads.

RESULTS:

1. If zero volts or residual voltage is indicated, go on to Test 3.
2. If the voltage reading is higher than residual, but is lower than the stated limits, go to Test 11.
3. If a high voltage is indicated, go on to Test 11.

NOTE: "Residual" voltage may be defined as the voltage that is produced by rotor residual magnetism alone. The amount of voltage induced into the stator AC power windings by residual voltage alone will be approximately 2 to 16 volts AC, depending on the characteristics of the specific generator. If a unit is supplying residual voltage only, either excitation current is not reaching the rotor or the rotor windings are open and the excitation current cannot pass. On current units with air-cooled engine, "field boost" current flow is available to the rotor only during engine cranking.

TEST 3- TEST EXCITATION CIRCUIT BREAKER

DISCUSSION:

Unregulated excitation current is delivered to the voltage regulator from the stator excitation (DPE) winding, via Wire 2, an excitation circuit breaker (CB2), Wire 162, and Wire 6. If the excitation circuit breaker has failed open, excitation current will not be available to the voltage regulator or to the rotor. Stator AC power winding output will then be reduced to a voltage that is the product of residual magnetism alone.

PROCEDURE:

1. With the generator shut down for at least two minutes, locate the excitation circuit breaker in the generator panel. Disconnect wires from the breaker, to prevent interaction.
2. Set a volt-ohm-milliammeter (VOM) to its "R x 1'scale and zero the meter.
3. Connect the VOM test probes across the circuit breaker terminals. The meter should read CONTINUITY.

RESULTS:

1. Replace circuit breaker if defective (meter reads “OPEN”). Then proceed to Test 4.
2. If circuit breaker is good, go on to Test 4.

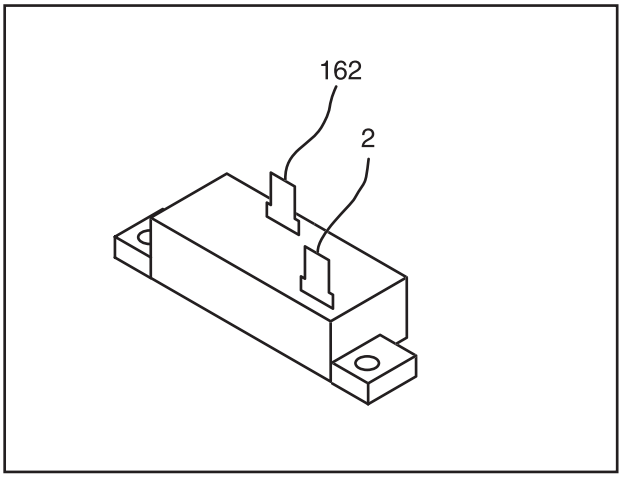


Figure 2. Excitation Circuit Breaker

TEST 4- FIXED EXCITATION TEST /ROTOR AMP DRAW TEST

DISCUSSION:

Supplying a fixed DC current to the rotor will induce a magnetic field in the rotor. With the generator running, this should create a proportional voltage output from the stator windings.

PROCEDURE:

1. Disconnect Wire 4 from the voltage regulator, 3rd terminal from the top. See Figure 3.
2. Connect a jumper wire to the disconnected Wire 4 and to the 12 volt fused battery supply Wire 15. (located at 15A fuse).

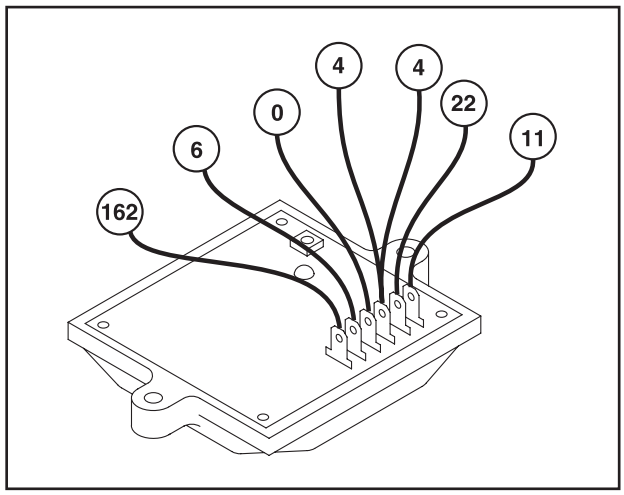


Figure 3. Voltage Regulator

3. Set VOM to AC volts.
4. Disconnect Wire 2 from the excitation circuit breaker (CB2) and connect one meter test lead to that wire. Disconnect Wire 6 from the voltage regulator and connect the other meter test lead to that wire. (5th terminal from top, double check wire number).
5. Set the AUTO-OFF-MANUAL switch to MANUAL. Once the engine starts, record the AC voltage.
6. Set the AUTO-OFF-MANUAL switch to OFF. Reconnect Wire 2 and Wire 6.
7. Disconnect Wire 11 from the voltage regulator and connect one meter test lead to that wire. Disconnect Wire 22 from the voltage regulator and connect the other meter test lead to that wire (both wires are located at the top two terminals of the voltage regulator, see Figure 3).

TEST 4 RESULTS - FIXED EXCITATION TEST/ROTOR AMP DRAW TEST

Results:	Size	A	B	C	D	E	F	G	H
Voltage Results Wire 2 & 6	ALL	Above 60 VAC	Above 60 VAC	Below 60 VAC	Zero or Residual Volts	Below 60 VAC	Below 60 VAC	Above 60 VAC	Below 60 VAC
Voltage Results Wire 11 & 22	ALL	Above 60 VAC	Below 60 VAC	Above 60 VAC	Zero or Residual Volts	Below 60 VAC	Below 60 VAC	Above 60 VAC	Below 60 VAC
Static Rotor Amp Draw	6 & 7 kW 12 & 12 kW 13 & 15 kW	0.91-1.06A 0.80A 0.64A	0.91-1.06A 0.80A 0.64A	0.91-1.06A 0.80A 0.64A	Zero Current Draw	Above 1.5A Above 1.3A Above 1.1A	0.91-1.06A 0.80A 0.64A	Zero Current Draw	0.91-1.06A 0.80A 0.64A
Running Rotor Amp Draw	6 & 7 kW 12 & 12 kW 13 & 15 kW	0.91-1.06A 0.80A 0.64A	0.91-1.06A 0.80A 0.64A	0.91-1.06A 0.80A 0.64A	Zero Current Draw	Above 1.5A Above 1.3A Above 1.1A	0.91-1.06A 0.80A 0.64A	Zero Current Draw	Above 1.5A Above 1.3A Above 1.1A

MATCH RESULTS WITH LETTER AND REFER TO FLOW CHART IN SECTION 2.3 "Problem 1"

8. Set the Auto-Off-Manual switch to MANUAL. Once the engine starts, record the AC voltage.
9. Set the Auto-Off-Manual switch to OFF. Reconnect Wire 11 and Wire 22.
10. Set VOM to DC amperage.
11. Remove jumper lead connected to Wire 4 and Wire 15.
12. Connect one meter test lead to battery positive twelve-volt supply Wire 15, located at the 15A fuse. Connect the other meter test lead to Wire 4 (still disconnected from previous tests). Measure and record static rotor amp draw.
13. Set the Auto-Off-Manual switch to the MANUAL position. Once the engine starts, repeat step 12. Measure and record running rotor amp draw with the engine running.
14. Set the Auto-Off -Manual switch to OFF. Reconnect Wire 4 to the voltage regulator.

RESULTS:

Refer to Chart on previous page : “Results - Fixed Excitation Test/Rotor Amp Draw Test.”.

TEST 5: WIRE CONTINUITY

DISCUSSION:

The voltage regulator receives unregulated alternating current from the stator excitation winding, via Wires 2, 6, and 162. It also receives voltage sensing from the stator AC power windings, via Wires 11 and 22. The regulator rectifies the AC from the excitation winding and based on the sensing signals, regulates the DC current flow to the rotor. The rectified and regulated current flow is delivered to the rotor brushes via Wires 4 (positive) and 0 (negative). This test will verify the integrity of Wires 0 and 162.

PROCEDURE:

1. Set VOM to its "R x 1" scale.
2. Remove Wire 0 from the voltage regulator, 4th terminal from the top. Also voltage regulator is labeled (-) next to terminal.
3. Connect one test lead to Wire 0, connect the other test lead to a clean frame ground. The meter should read CONTINUITY.
4. Disconnect Wire 162 from the voltage regulator, 6th terminal from the top. Disconnect the other end of Wire 162 from the excitation circuit breaker. Connect one test lead to one end of Wire 162, and the other test lead to the other end of Wire 162. The meter should read CONTINUITY.

RESULTS:

If CONTINUITY was not measured across each wire, repair or replace the wires as needed.

TEST 6 - CHECK FIELD BOOST

DISCUSSION:

See "Field Boost Circuit" in Section 2.2. Field boost current (from the circuit board) is available to the rotor only while the engine is cranking. Loss of field boost output to the rotor may or may not affect power winding AC output voltage. The following facts apply:

- A small amount of voltage must be induced into the DPE winding to turn the voltage regulator on.
- If rotor residual magnetism is sufficient to induce a voltage into the DPE winding that is high enough to turn the voltage regulator on, regulator excitation current will be supplied even if field boost has failed. Normal AC output voltage will then be supplied.
- If rotor residual magnetism has been lost or is not sufficient to turn the regulator on, and field boost has also been lost, excitation current will not be supplied to the rotor. Generator AC output voltage will then drop to zero or nearly zero.

PROCEDURE:

1. Locate Wire 4 that is routed from the circuit board and connects to the voltage regulator terminal, third from the top (see Figure 3). Disconnect that wire from the voltage regulator terminal.
2. Set a VOM to read DC volts. Disconnect Connector C2 from the control panel (C2 is the closest to the back panel).
3. Connect the positive (+) VOM test probe to the terminal end of disconnected Wire 4.
4. Connect the common (-) VOM test probe to the grounding lug.
5. Crank the engine while observing the VOM reading. While the engine is cranking, the VOM should read approximately 9-10 volts DC. When engine is not cranking, VOM should indicate "zero" volts (see Figure 4).

RESULTS:

1. If normal field boost voltage is indicated in Step 5, replace the voltage regulator.
2. If normal field boost voltage is NOT indicated in Step 5, check Wire 4 (between regulator and circuit board) for open or shorted condition. If wire is good, replace the circuit board.

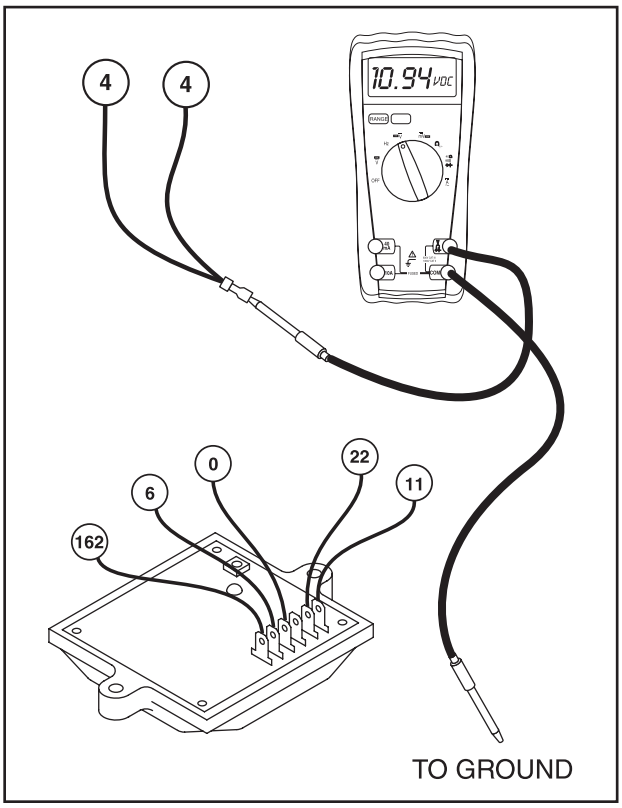


Figure 4. Field Boost Test Points

TEST 7: TESTING THE STATOR WITH A VOM

DISCUSSION:

A Volt-OHM-Milliammmeter (VOM) can be used to test the stator windings for the following faults:

- An open circuit condition
- A "short-to-ground" condition
- A short circuit between windings

Note: The resistance of stator windings is very low. Some meters will not read such a low resistance, and will simply indicate CONTINUITY. Recommended is a high quality, digital type meter capable of reading very low resistances.

PROCEDURE:

1. Disconnect stator leads 11 and 44 from the main circuit breaker.
2. Disconnect stator leads 22 and 33 from the neutral connection separate the leads.
3. Disconnect Connector C2 from the side of the control panel (C2 is the closest to the back panel). See Figure 9, page 128 for connector location.
4. Make sure all off the disconnected leads are isolated from each other and are not touching the frame during the test.
5. Set a VOM to its "R x 1" scale and zero the meter.
6. Refer to Figure 5 for pin locations of Connector C2. Use a large paper clip or similar metallic object to access pins in connector C2.

Note: Pins 9, 10, 11 & 12 are not used for this test.

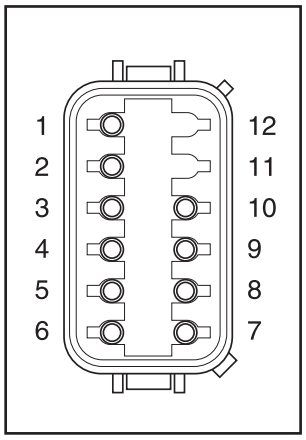


Figure 5. C2 Connector Pin Locations (Female Side)

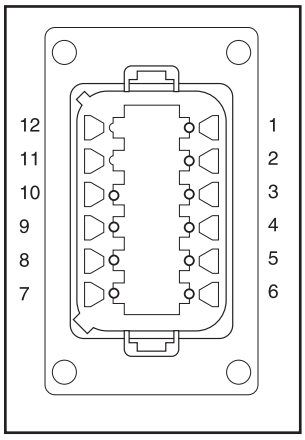


Figure 6. C2 Connector Pin Locations (Male Side)

7. Connect one test lead to stator lead Wire 11. Connect the other test lead to stator lead Wire 22 (power winding). Note the resistance reading and compare to the specifications on inside front cover.
8. Connect one test lead to stator lead Wire 33. Connect the other test lead to stator lead Wire 44 (power winding). Note the resistance reading and compare to the specifications on inside front cover.
9. Connect one test lead to Pin 1. Connect the other test lead to Pin 2 (battery charge winding). Note the resistance reading, compare to specifications on inside front cover.
10. Connect one test lead to Pin 3. Connect the other test lead to Pin 4 (engine run winding). Note the resistance reading, compare to specification inside front cover.
11. Connect one test lead to Pin 5. Connect the other test lead to Pin 6 (power winding-sense leads). Note the resistance reading, compare to specification inside front cover.
12. Connect on test lead to Pin 7. Connect the other test lead to Pin 8 (excitation winding). Note the resistance reading, compare to specification inside front cover.

TEST WINDINGS FOR A SHORT TO GROUND:

13. Make sure all leads are isolated from each other and are not touching the frame.
14. Set a VOM to its "R x 10,000" or "R x 1K" scale and zero the meter
15. Connect one test lead to a clean frame ground. Connect the other test lead to stator lead Wire 11.
    a. The meter should read INFINITY
    b. Any reading other than INFINITY indicates a "short-to-ground" condition.
16. Repeat Step 15 using stator lead Wire 33.
17. Repeat Step 15 using Pin 1.
18. Repeat Step 15 using Pin 3
19. Repeat Step 15 using Pin 5
20. Repeat Step 15 using Pin 7

TEST FOR A SHORT CIRCUIT BETWEEN WINDINGS:

21. Set a VOM to its "R x 10,000" or "R x 1K" scale and zero the meter.
22. Connect one test lead to stator lead Wire 11. Connect the other test lead to stator lead Wire 33.
    a. The meter should read infinity.
    b. Any reading other than INFINITY indicates a short circuit between windngs.
23. Repeat Step 22 using stator lead Wire 11; Pin 1
24. Repeat Step 22 using stator lead Wire 11; Pin 3
25 Repeat Step 22 using stator lead Wire 11; Pin 7
26. Repeat Step 22 using stator lead Wire 33; Pin 1
27. Repeat Step 22 using stator lead Wire 33; Pin 3
28. Repeat Step 22 using stator lead Wire 33; Pin 7
29. Repeat Step 22 using Pin 1; Pin 3
30. Repeat Step 22 using Pin 1; Pin 7
31. Repeat Step 22 using Pin 3; Pin 7

TEST CONTROL PANEL WIRES FOR CONTINUITY:

32. Set a VOM to its "Rx1" scale.
33. Disconnect the C2 connector from the control panel. (C2 is the closest to the back panel). Refer to Figure 6 for pin locations.
33. Connect one meter test lead to Pin 5 of the C2 connector, connect the other test lead to Wire 22 at the voltage regulator. Continuity should be measured.
34. Connect one meter test lead to Pin 6 of the C2 connector, connect the other test lead to Wire 11 at the voltage regulator. Continuity should be measured.
35. Connect one meter test lead to Pin 7 of the C2 connector, connect the other test lead to Wire 6 at the voltage regulator. Continuity should be measured.
36. Connect one meter test lead to Pin 8 of the C2 connector, connect the other test lead to Wire 2 at CB2 (DPE circuit breaker). Continuity should be measured.

RESULTS:

1. Stator winding resistance values is a test of winding continuity and resistance. If a very high resistance or INFINITY is indicated, the winding is open or partially open.
2. Testing for a "grounded" condition: Any upscale movement of the meter needle or dial indicates the winding is grounded.
3. Testing for a "shorted" condition: Any upscale movement of the VOM needle or dial indicates the winding is shorted.
4. If the stator tests good and wire continuity tests good , perform “Insulation Resistance Test” in Section 1.4.
5. If any test of wire continuity failed in control panel failed, repair or replace the wire, terminal or pin connectors for that associated wire as needed.

NOTE: Read section 1.4, "Testing, Cleaning and Drying" carefully. If the winding tests good, perform an insulation resistance test. If the winding fails the insulation resistance test, clean and dry the stator as outlined in Section 1.4. Then, repeat the insulation resistance test. If the winding fails the second resistance test (after cleaning and drying), replace the stator assembly.

TEST 8 - RESISTANCE CHECK OF ROTOR CIRCUIT

DISCUSSION:

To verify the zero current draw reading and measure the rotor circuit.

PROCEDURE:

1. Disconnect Wire 4 from the voltage regulator. It is located 3rd terminal from the top of the volt regulator.
2. Set VOM to the "Rx1" scale.
3. Connect one test lead to Wire 4. Connect the other test lead to a clean frame ground. Note the resistance reading. Compare to specifications on inside front cover.

RESULTS:

1. If the resistance reading is correct, check your VOM meters fuse and repeat Test 4.
2. If INFINITY is measured on your VOM meter, go to Test 9.

TEST 9 - CHECK BRUSHES AND SLIP RINGS

DISCUSSION:

The function of the brushes and slip rings is to provide for passage of excitation current from stationary components to the rotating rotor. Brushes are made of a special long lasting material and seldom wear out or fail. However, slip rings can develop a tarnish or film that can inhibit or offer a resistance to the flow of electricity. Such a non-conducting film usually develops during non-operating periods. Broken or disconnected wiring can also cause loss of excitation current to the rotor.

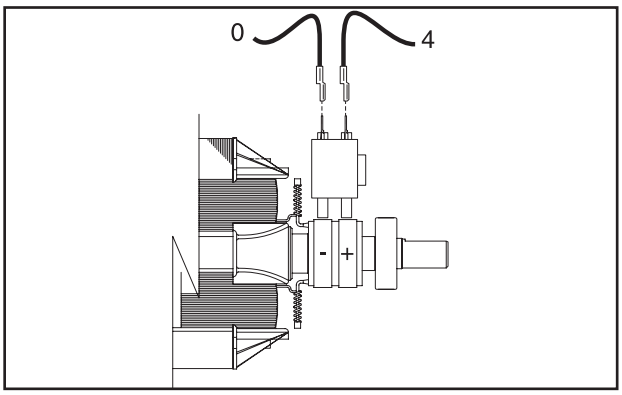


Figure 7. Checking Brushes and Slip Rings

PROCEDURE:

1. Disconnect connector C2 (deutsch connector closest to the back panel). Refer to Figure 5 and Figure 6 in Section 2.4.
2. Set a VOM to measure resistance.
3. Connect one meter test lead to Pin 9 (Wire 0) of the C2 connector (female side). Connect the other meter test lead to Pin 10 (Wire 4) of the C2 connector (female side). Rotor resistance should be measured see specifications on inside front cover. If rotor resistance is not measured proceed to step 4. If rotor resistance is measured proceed to step 12.
4. See figure 7. Carefully inspect brush wires; make sure they are properly and securely connected.
5. Wire 0 from the negative (-) brush terminal connects to Pin 9 of the C2 connector. Test this wire for an open condition. Remove wire 0 from the brush assembly. Connect one meter test lead to wire 0. Connect the other test lead to Pin 9 (wire 0) of the C2 connector (female side). CONTINUITY should be measured. If INFINITY is measured repair or replace wire 0 between the brush assembly and the C2 connector.
6. Wire 4 from the positive (+) brush terminal connects to Pin 10 of the C2 connector.Test this wire for an open condition. Remove wire 4 from the brush assembly. Connect one meter test lead to Wire 4. Connect the other meter test lead to Pin 10 (wire 0) of the C2 connector (female side). CONTINUITY should be measured. If INFINITY is measured repair or replace wire 4 between the brush assembly and the C2 connector.
7. Connect one meter test lead to wire 4 Connect the other meter test lead to frame ground. INFINITY should be measured. If CONTINUITY is measured a short to ground exists on wire 4 repair or replace wire 4 between the brush assembly and the C2 connector.
8. If continuity was measured in steps 5 and 6 proceed to step 9.
9. Disconnect wires 0 and 4 from the brush assembly. Remove the brush assembly from the bearing carrier. Inspect the brushes for excessive wear,damage.
10. Inspect the rotor slip rings. If they appear dull or tarnished, they may be polished with a fine sandpaper. DO NOT USE METALLIC GRIT TO POLISH SLIP RINGS.
11. If brush assembly and slip rings look good proceed to Test 10 (Test Rotor assembly)
12. Wire 0 connects from the C2 connector to the control panel ground lug. Connect one meter test lead to Pin 9 (Wire 0) of the C2 connector (male side). Connect the other meter test lead to the ground terminal in the control panel. CONTINUITY should be measured. If INFINITY is measured repair or replace wire 0 between the C2 connector and the ground terminal.
13. Remove wire 4 from the voltage regulator.
14. Connect one meter test lead to Pin 10 (wire 4) of the C2 connector (male side). Connect the other meter test lead to Wire 4 removed from the Voltage regulator. CONTINUITY should be measured. If INFINITY is measured repair or replace wire 4 between the C2 connector and the voltage regulator.

RESULTS:

1. Repair, replace or reconnect wires as necessary.
2. Replace any damaged slip rings or brush holder.
3. Clean and polish slip rings as required.

TEST 10 - TEST ROTOR ASSEMBLY

DISCUSSION:

A rotor having completely open windings will cause loss of excitation current flow and, as a result, generator AC output voltage will drop to "residual" voltage. A "shorted" rotor winding can result in a low voltage condition.

PROCEDURE:

1. Disconnect the brush wires or remove the brush holder, to prevent interaction.
2. Set a VOM to its "R x 1" scale and zero the meter.
3. Connect the positive (+) VOM test lead to the positive (+) rotor slip ring (nearest the rotor bearing); and the common (-) test lead to the negative (-) slip ring. The meter should read approximately 10-20 ohms. Compare to “Specifications,” inside front cover.
4. Now, set the VOM to a high resistance scale (such as "R x 10,000" or "R x 1K"). Again, zero the meter.
5. Connect the positive (+) VOM test lead to the positive (+) slip ring and the common (-) test lead to a clean frame ground. The meter should indicate infinity.

RESULTS:

1. Replace rotor assembly if it is open or shorted.
2. If rotor tests good, perform “Insulation Resistance Test” in Section 1.4.

NOTE: Be sure to read Section 1.4, "Testing, Cleaning and Drying", carefully. If the rotor tests good, try performing an insulation resistance test. Clean and dry the rotor if it fails that test. Then, repeat the test. If the rotor fails the second insulation resistance test, it should be replaced.

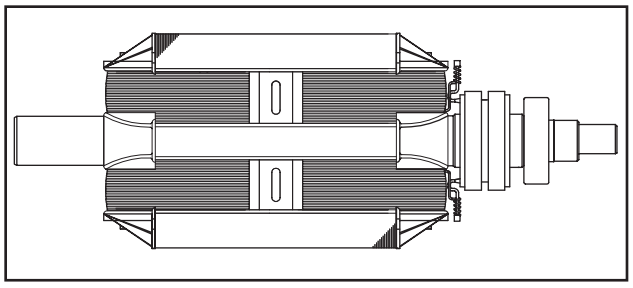


Figure 8. The Rotor Assembly

TEST 11 - CHECK AC OUTPUT FREQUENCY

DISCUSSION:

The generator AC frequency is proportional to the operating speed of the rotor. The 2-pole rotor will supply a 60 Hertz AC frequency at 3600 rpm. The unit's AC output voltage is proportional to the AC frequency. For example, a unit rated 240 volts (line-to-line) will supply that rated voltage (plus or minus 2 percent) at a frequency of 60 Hertz. If, for any reason, the frequency should drop to 30 Hertz, the line-to-line voltage will drop to a matching voltage of 120 volts AC. Thus, if the AC voltage output is high or low and the AC frequency is correspondingly high or low, the engine speed governor may require adjustment.

PROCEDURE:

1. Connect an accurate AC frequency meter across the Wires 11 and 44 terminals of the generator main line circuit breaker (see Figure 1, Section 2.4).
2. Start the engine, let it stabilize and warm up at no-load.
3. When engine has stabilized, read the frequency meter. The no-load frequency should be about 61-63 Hertz.

RESULTS:

1. If the AC frequency is high or low, go on to Test 12.
2. If frequency is good, but voltage is high or low, go to Test 13.
3. If frequency and voltage are both good, tests may be discontinued.

TEST 12 - CHECK AND ADJUST ENGINE GOVERNOR

DISCUSSION:

The generator AC frequency output is directly proportional to the speed of the rotor. A two-pole rotor (having a single north and a single south magnetic pole) will produce an AC frequency of 60 hertz at 3600 RPM.

The generator is equipped with a "voltage over frequency" type AC voltage regulator. The units AC output voltage is

generally proportional to AC frequency. A low or high governor speed will result in a correspondingly low or high AC frequency and voltage output. The governed speed must be adjusted before any attempt to adjust the voltage regulator is made.

PROCEDURE (7KW UNITS):

1. Loosen the governor clamp bolt (Figure 9).
2. Hold the governor lever at its wide open throttle position, and rotate the governor shaft clockwise as far as it will go. Then, tighten the governor lever clamp bolt to 70 inch-pounds (8 N-m).

3. Start the generator; let it stabilize and warm up at no-load.
4. Connect a frequency meter across the generators AC output leads.
5. Turn the primary adjust screw to obtain a frequency reading of 61.5 Hertz. Turn the secondary adjust screw to obtain a frequency of 62.5 Hz.
6. When frequency is correct at no load, check the AC voltage reading. If voltage is incorrect, the voltage regulator may require adjustment.

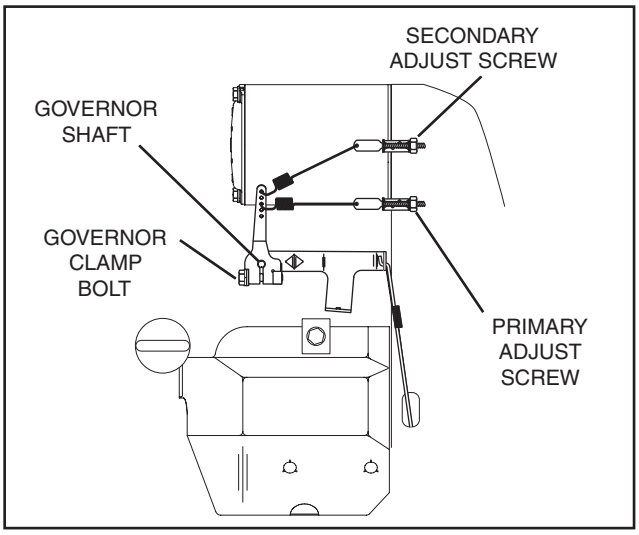


Figure 9. Engine Governor Adjustment Single Cylinder Engines

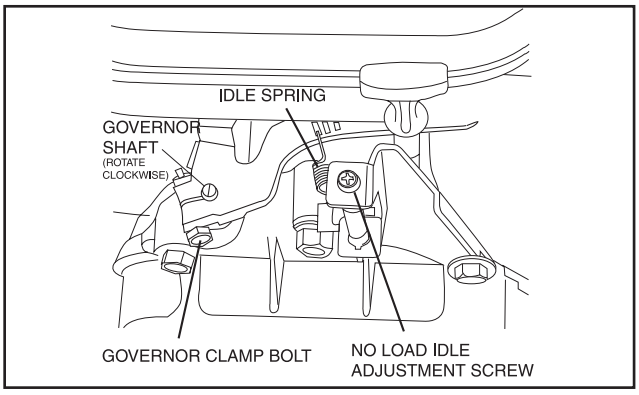


Figure 10. Engine Governor Adjustment V-twin Engines

PROCEDURE (12/15 KW UNITS):

1. Loosen governor clamp bolt (See Figure 10).
2. Completely remove the idle spring.
3. With governor arm at wide open throttle position, rotate governor shaft fully clockwise. Tighten clamp bolt to 84 inch-pounds.
4. Start unit and apply full load. Use full load speed adjust screw (Figure 11) to adjust frequency to 58 Hz.
5. Remove load, stop engine, loosen the idle adjust screw and reconnect the idle spring.
6. Using your hand, push the governor arm to the closed throttle position. Make sure the idle spring does not stretch at all.
7. Restart the unit.
8. Slowly turn the idle adjust screw to adjust the no-load idle speed to 62.5 Hz.
9. The governor is now set.

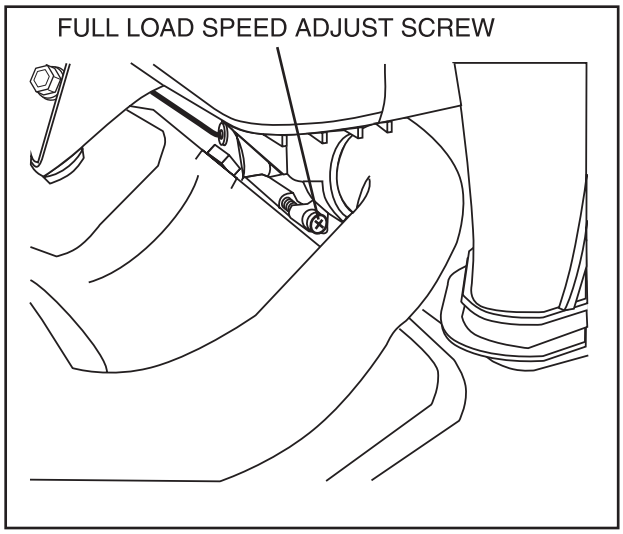


Figure 11. Full Load Speed Adjust Screw V-twin Engines

RESULTS:

1. If, after adjusting the engine governor, frequency and voltage are good, tests may be discontinued.
2. If frequency is now good, but voltage is high or low, go to Test 13.
3. If engine was overspeeding, check linkage and throttle for binding. If no governor response is indicated refer to engine service manual.
4. If engine appears to run rough and results in low frequency, proceed to Problem 11, Section 4.3.

TEST 13 - CHECK AND ADJUST VOLTAGE REGULATOR

DISCUSSION:

For additional information, refer to description and components Section 2.1.

PROCEDURE:

With the frequency between 61-62 Hertz, slowly turn the slotted potentiometer (Figure 12) until line voltage reads 244-252 volts.

NOTE: You must remove the access panel on top of the control panel to adjust the voltage regulator.

NOTE: The voltage regulator is housed above the generator control panel. The regulator maintains a voltage in direct proportion to frequency at a 2-to-1 ratio. For example, at 62 Hertz, line-to-neutral voltage will be 124 volts.

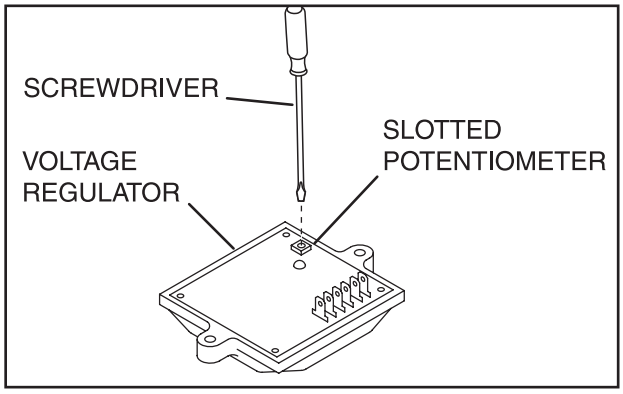


Figure 12. Voltage Adjustment Potentiometer

RESULTS:

1. If the frequency and voltage are now good, discontinue tests.
2. If frequency is now good but voltage is high or low, go to Problem 1, Test 4.

TEST 14 - CHECK VOLTAGE AND FREQUENCY UNDER LOAD

DISCUSSION:

It is possible for the generator AC output frequency and voltage to be good at no-load, but they may drop excessively when electrical loads are applied. This condition, in which voltage and frequency drop excessively when loads are applied, can be caused by (a) overloading the generator, (b) loss of engine power, or (c) a shorted condition in the stator windings or in one or more connected loads.

PROCEDURE:

1. Connect an accurate AC frequency meter and an AC voltmeter across the stator AC power winding leads.
2. Start the engine, let it stabilize and warm-up.
3. Apply electrical loads to the generator equal to the rated capacity of the unit.
4. Check the AC frequency and voltage. Frequency should not drop below approximately 58-59 Hertz. Voltage should not drop below about 230 volts (plus or minus 2 percent).

RESULTS:

1. If frequency and voltage drop excessively under load, go to Test 15.
2. If frequency and voltage under load are good, discontinue tests.

TEST 15 - CHECK FOR OVERLOAD CONDITION

DISCUSSION:

An "overload' condition is one in which the generator rated wattage/amperage capacity has been exceeded. To test for an overload condition on an installed unit, the best method is to use an ammeter. See "Measuring Current" in Section 1.4.

PROCEDURE:

Use a clamp-on ammeter to measure load current draw, with the generator running and all normal electrical loads turned on.

RESULTS:

1. If the unit is overloaded, reduce loads to the unit's rated capacity.
2. If unit is not overloaded, but rpm and frequency drop excessively when loads are applied, go to Test 16.

TEST 16 - CHECK ENGINE CONDITION

DISCUSSION:

If engine speed and frequency drop excessively under load, the engine may be under-powered. An under-powered engine can be the result of a dirty air cleaner, loss of engine compression, faulty carburetor settings, incorrect ignition timing, etc.

PROCEDURE:

For engine testing, troubleshooting and repair procedures refer to Problem 11 in Section 4.3. For further engine repair information refer to the following manuals:

- P/N 0C1103 - Service and Repair Manual for Single Cylinder GN Engines.
- P/N 0E2081 - Service Manual for GTV-990/760 V-Twin OHVI Engines.

PART 3
"V-TYPE" PREPACKAGED TRANSFER SWITCHES

Air-cooled, Prepackaged Automatic Standby Generators

Models:
6 kW NG, 7 kW LP
12 kW NG, 12 kW LP
13 kW NG, 15 kW LP

TABLE OF CONTENTS

PART	TITLE
3.1	Description and Components
3.2	Operational Analysis
3.3	Troubleshooting Flow Charts
3.4	Diagnostic Tests

GENERAL

The prepackaged, "V-Type" transfer switch is rated 100 amps at 250 volts maximum. It is available in 2-pole configuration only and, for that reason, is useable with 1-phase systems only.

Prepackaged transfer switches do not have an intelligence system of their own. Instead, automatic operation of these transfer switches is controlled by a circuit board housed in the generator control panel.

ENCLOSURE

The standard prepackaged, "V-Type" transfer switch enclosure is a NEMA 1 type ("NEMA" stands for "National Electrical Manufacturer's Association"). Based on NEMA Standard 250, the NEMA 1 enclosure may be defined as one that is intended for indoor use primarily to provide a degree of protection against contact with the enclosed equipment and where unusual service conditions do not exist.

The 2-pole transfer mechanism consists of a pair of moveable LOAD contacts, a pair of stationary

ITEM	DESCRIPTION
1	BOX GTS LOAD CENTER
2	COVER, 12 POSITION GTS LOAD CENTER
3	TRANSFER SWITCH HOME STANDBY 100A2P250V
4	SCREW TAPTITE M5-0.8 X 10 BP
5	SCREW TAPTITE 1/4-20 X 5/8 BP
6	LOCK WASHER, SPECIAL-1/4"
7	RELAY PANEL 12VDC DPDT 10A@240VA
8	BASE, MOUNTING 12 CIRCUIT 125A/240V
9	SCREW TAPTITE M4-0.7X10 BP
10	RIVET POP .156 X .160-.164/#20
11	WASHER FLAT 1/4 ZINC
12	PLUG
13	HARNESS ADAPTER PLATE
14	PANEL-SUB BREAKER BASE
15	TRIM VINYL BLACK 1/8GP
16	WASHER LOCK #10
17	NUT WING M6-1.0
18	HANDLE, TRANSFER SWITCH HOME STANDBY
19	HOLDER CABLE TIE
21	LUG DIS QK NI-S 10X45 DEG BR/T
22	SCREW PPHM #10-32 X 1/4
23	LUG SLDLSS 1/0-#14X9/16 AL/CU
24	BLOCK TERMINAL 20A 5 X 6 X 1100V
25	TIE WRAP 3.9" X .10" NAT'L UL
26	WASHER FLAT #8 ZINC
27	COVER, RELAY & TERM BLOCK
28	WIRE HARNESS,GTS LOAD CENTER (NOT SHOWN FOR CLARITY)
29	FUSE HOLDER
30	ASSEMBLY FUSE 5A X BUSS HLDR73591
31	PCB SUPPORT SNAP-IN 1-3/8"
32	CIRCT BRK 20 X 1 HOM120
33	CIRCT BRK 20 X 2 HOM220
34	CIRCT BRK 15 X 1 HOM115
35	CIRCT BRK 30 X 2 HOM230
36	COVER - HARNESS ENTRY
37	HARNESS, GTS TO EXT CONN BOX
38	WASHER LOCK M4
39	SCREW SW 1/4-20X5/8 N WA JS500
40	SCREW SWAGE 1/4-20 X 1/2 ZINC
41	SCREW PPHM M4-0.7 X 10
42	HARNESS,GTS TO MAIN PANEL

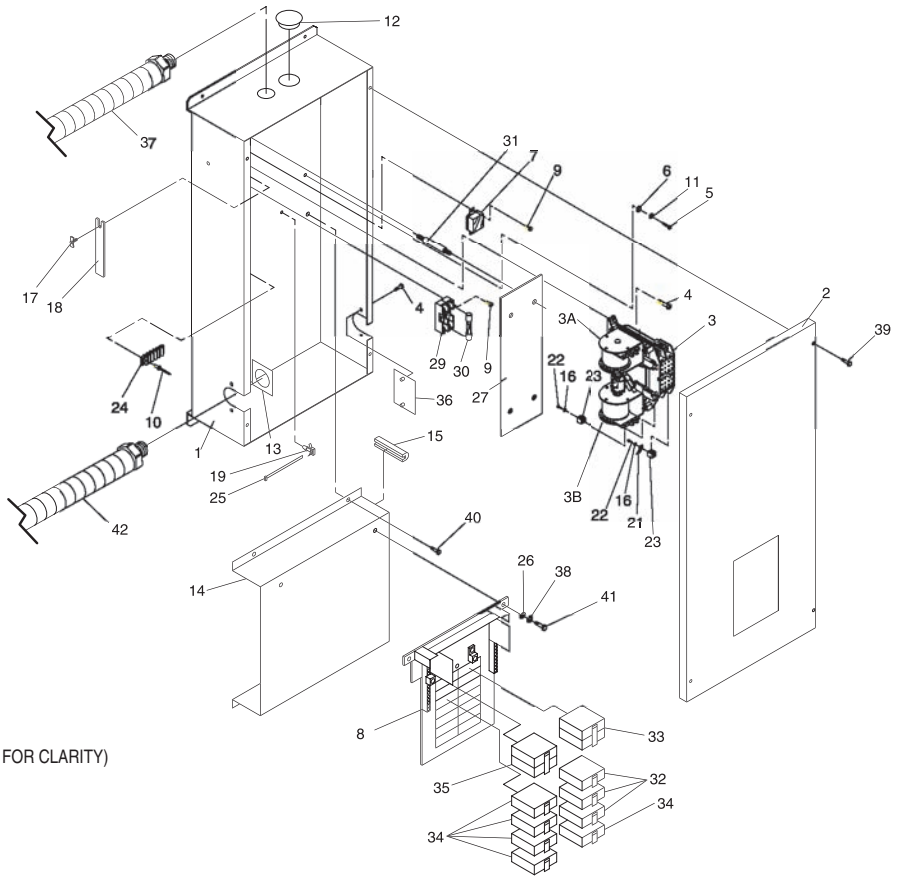


Figure 1. Exploded View of V-Type Prepackaged Transfer Switch

UTILITY contacts, and a pair of stationary STANDBY contacts. The load contacts can be connected to the utility contacts by a utility closing coil; or to the standby contacts by a standby closing coil. In addition, the load contacts can be actuated to either the UTILITY or STANDBY side by means of a manual transfer handle. See Figures 2 and 3.

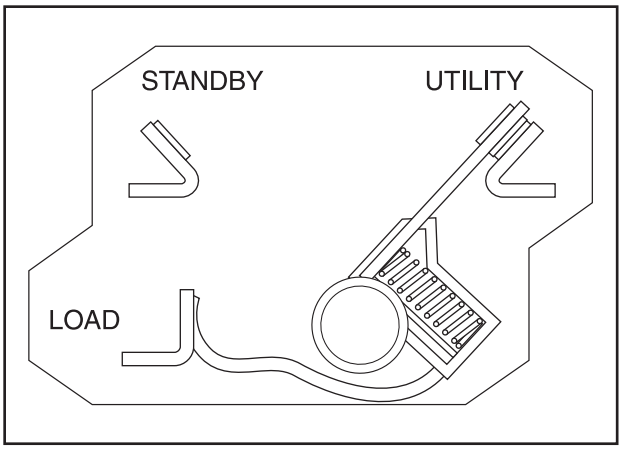


Figure 2. Load Connected to Utility Power Source

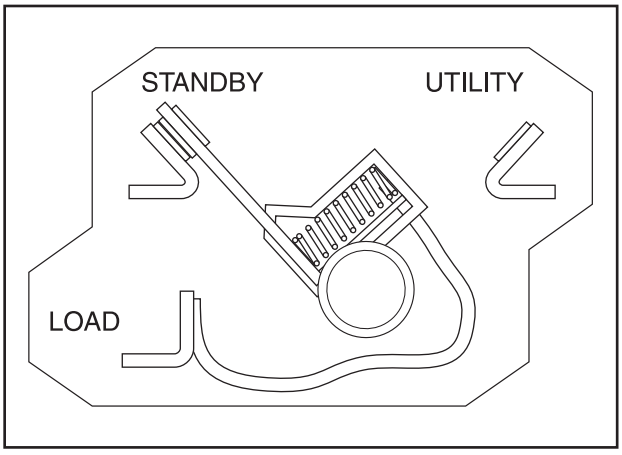


Figure 3. Load Connected to Standby Power Source

UTILITY CLOSING COIL C1:

See Figure 4. This coil is energized by rectified utility source power, to actuate the load contacts to the UTILITY power source side. When energized, the coil will move the main contacts to an "overcenter" position. A limit switch will then be actuated to open the circuit and spring force will complete the retransfer to STANDBY. A bridge rectifier, which changes the utility source alternating current (AC) to direct current (DC), is sealed in the coil wrappings. If coil or bridge rectifier replacement becomes necessary, the entire coil and bridge assembly should be replaced.

STANDBY CLOSING COIL C2:

Coil C2 is energized by rectified standby source power, to actuate the load contacts to their "Standby" source side. Energizing the coil moves the load contacts to an overcenter position; limit switch action then opens the circuit and spring force will complete the transfer action to "Standby". This coil's bridge rectifier is also sealed in the coil wrappings. Replace the coil and bridge rectifier as a unit.

LIMIT SWITCHES XA1 AND XB1:

Switches are mechanically actuated by load contacts movement. When the load contacts are connected to the utility contacts, limit switch XA1 opens the utility circuit to utility closing coil C1 and limit switch XB1 closes the standby circuit to standby closing coil C2. The limit switches "arm" the system for retransfer back to UTILITY when the load contacts are connected to the STANDBY side. Conversely, when the load contacts are connected to the UTILITY side, the switches "arm" the system for transfer to STANDBY. An open condition in limit switch XA1 will prevent retransfer to "Utility". An open switch XB1 will prevent transfer to STANDBY.

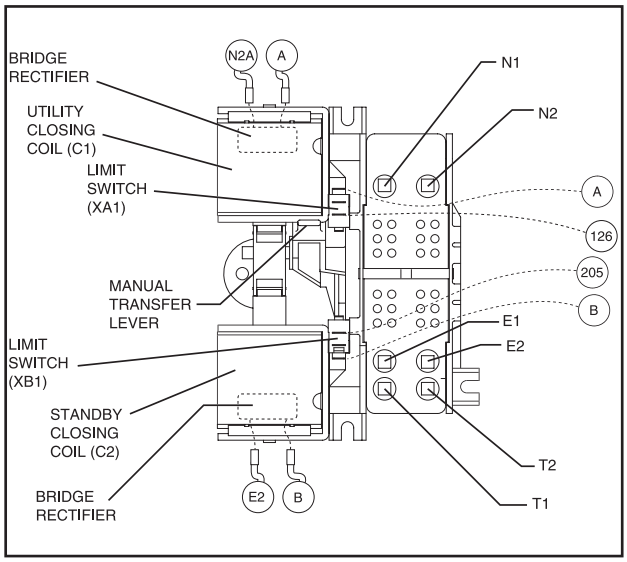


Figure 4. The "V-Type" Transfer Mechanism

TRANSFER RELAY

Transfer relay operation is controlled by a circuit board. That circuit board is a part of a control panel assembly, mounted on the standby generator set.

Figure 5 shows the transfer relay pictorially and schematically. Relay operation may be briefly described as follows:

1. Generator battery voltage (12 volts DC) is available to the transfer relay coil from the generator circuit board, via Wire 194 and relay terminal A.

a. The 12 volts DC circuit is completed through the transfer relay coil and back to the generator circuit board, via Wire 23.

b. Circuit board action normally holds the Wire 23 circuit open to ground and the relay is de-energized.

c. When de-energized, the relay's normally open contacts are open and its normally-closed contacts are closed.

d. The normally-closed relay contacts will deliver utility source power to the utility closing circuit of the transfer mechanism.

e. The normally open relay contacts will deliver standby source power to the transfer mechanism's standby closing circuit.

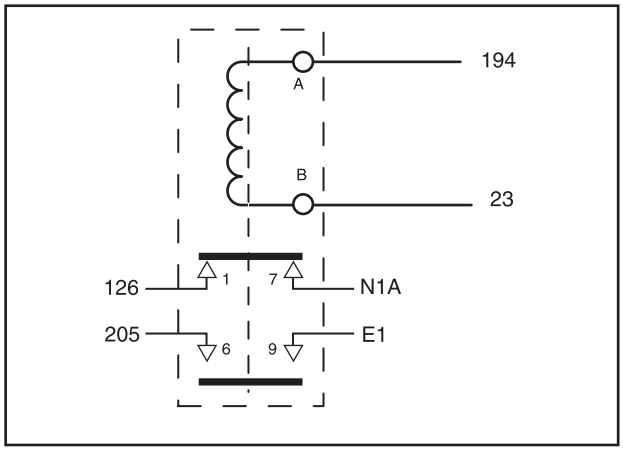


Figure 5. Transfer Relay Schematic

2. During automatic system operation, when the generator circuit board "senses" that utility source voltage has dropped out, the circuit board will initiate engine cranking and startup.

3. When the circuit board "senses" that the engine has started, an "engine warm-up timer" on the circuit board starts timing.

4. When the "engine warm-up timer" has timed out, circuit board action completes the Wire 23 circuit to ground.

   a. The transfer relay then energizes.

   b. The relay's normally-closed contacts open and its normally open contacts close.

   c. When the normally open contacts close, standby source power is delivered to the standby closing coil and transfer to "Standby" occurs.

5. When the generator circuit board "senses" that utility source voltage has been restored above a preset level, the board will open the Wire 23 circuit to ground.

   a. The transfer relay will de-energize, its normally-closed contacts will close and its normally open contacts will open.

   b. When the normally-closed relay contacts close, utility source voltage is delivered to the utility closing coil to energize that coil.

   c. Retransfer back to UTILITY occurs.

NEUTRAL LUG

The standby generator is equipped with an UNGROUNDED neutral. The neutral lug in the transfer switch is isolated from the switch enclosure.

MANUAL TRANSFER HANDLE

The manual transfer handle is retained in the transfer switch enclosure by means of a wing stud. Use the handle to manually actuate the transfer mechanism load contacts to either the UTILITY or STANDBY source side.

Instructions on use of the manual transfer handle may be found in Part 5, "Operational Tests and Adjustments".

TERMINAL BLOCK

During system installation, this 5-point terminal block must be properly interconnected with an identically labeled terminal block in the generator control panel assembly.

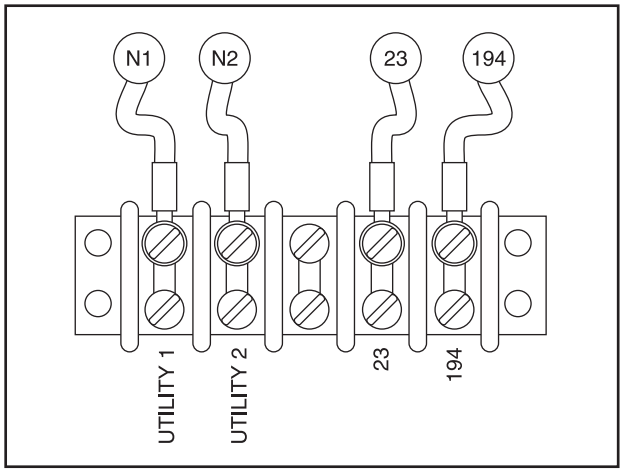


Figure 6. Transfer Switch Terminal Block

Terminals used on the terminal block are identified as Utility 1 and 2; 23 and 194.

UTILITY 1 AND 2:

Interconnect with identically labeled terminals in the generator control panel assembly. This is the utility voltage signal to the circuit board. The signal is

delivered to a step-down transformer in the control module assembly and the resultant reduced voltage is then delivered to the circuit board. Utility 1 and 2 power is used by the circuit board as follows:

- If utility source voltage should drop below a preset level, circuit board action will initiate automatic cranking and startup, followed by automatic transfer to the standby source.
- Utility source voltage is used to operate a battery trickle charge circuit which helps to maintain battery state of charge during non-operating periods.

TERMINALS 23 AND 194:

These terminals connect the transfer relay to the generator circuit board. See "Transfer Relay" in Section 3.1.

FUSE HOLDER

The fuse holder holds two (2) fuses, designated as fuses F1 and F2. Each fuse is rated 5 amperes.

FUSES F1, F2:

These two fuses protect the terminal board UTILITY 1 and 2 circuit against overload.

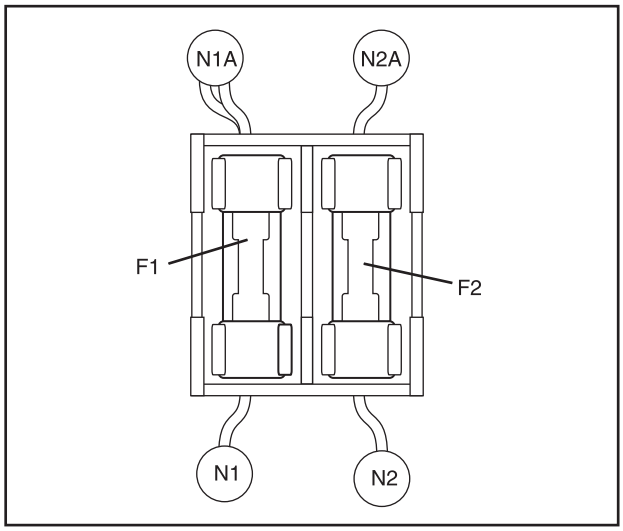
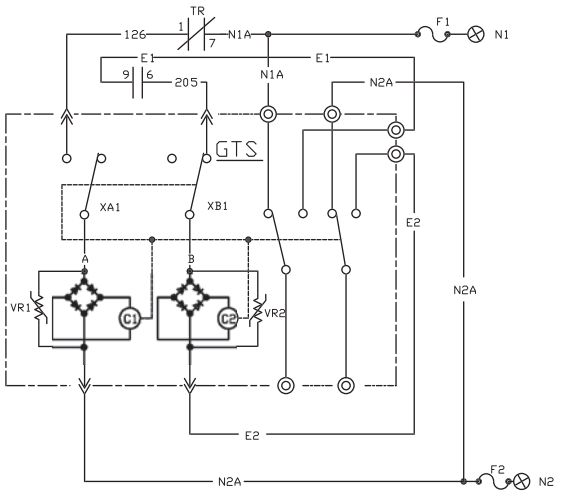


Figure 7. The Fuse Holder

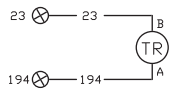
OPERATIONAL ANALYSIS

Figure 1 is a schematic and wiring diagram for a typical "V-Type" transfer switch.

SCHEMATIC DIAGRAM



LEGEND
C1- SOLENOID COIL (UTILITY CLOSING)
C2- SOLENOID COIL (STANDBY CLOSING)
GTS - TRANSFER SWITCH CONTACTOR
TR - RELAY, TRANSFER
TS - TERMINAL STRIP (CUSTOMER CONNECTION)
XA1, XB1- LIMIT SWITCHES, ACTUATOR
F1, F2 - FUSE, 5A SENSING
VR1, VR2 - VARISTOR



NOTE:
ALL CONTACTS SHOWN WITH TRANSFER SWITCH IN UTILITY POSITION.

WIRING DIAGRAM

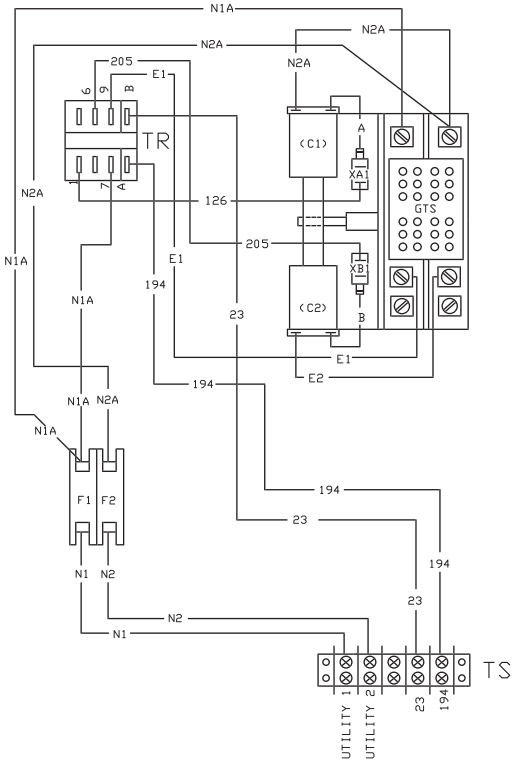


Figure 1. Wiring Diagram and Schematic

UTILITY SOURCE VOLTAGE AVAILABLE

Figure 2 is a schematic representation of the transfer switch with utility source power available. The circuit condition may be briefly described as follows:

- Utility source voltage is available to terminal lugs N1 and N2 of the transfer mechanism, transfer switch is in the UTILITY position and source voltage is available to T1, T2 and customer load.
- Utility source voltage is available to limit switch (XA1) via the normally-closed transfer relay contacts (1 and 7) and Wire 126. However, XA1 is open and the Circuit to the utility closing coil is open.
- Utility voltage "sensing" signals are delivered to a circuit board on the generator, via Wire N1A, a 5 amp fuse (F1), transfer switch terminal N1, generator terminal N1 and a sensing transformer. The second line of the utility voltage "sensing" circuit is via Wire N2A, a 5 amp Fuse (F2), transfer switch terminal N2, generator terminal N2, and the sensing transformer.

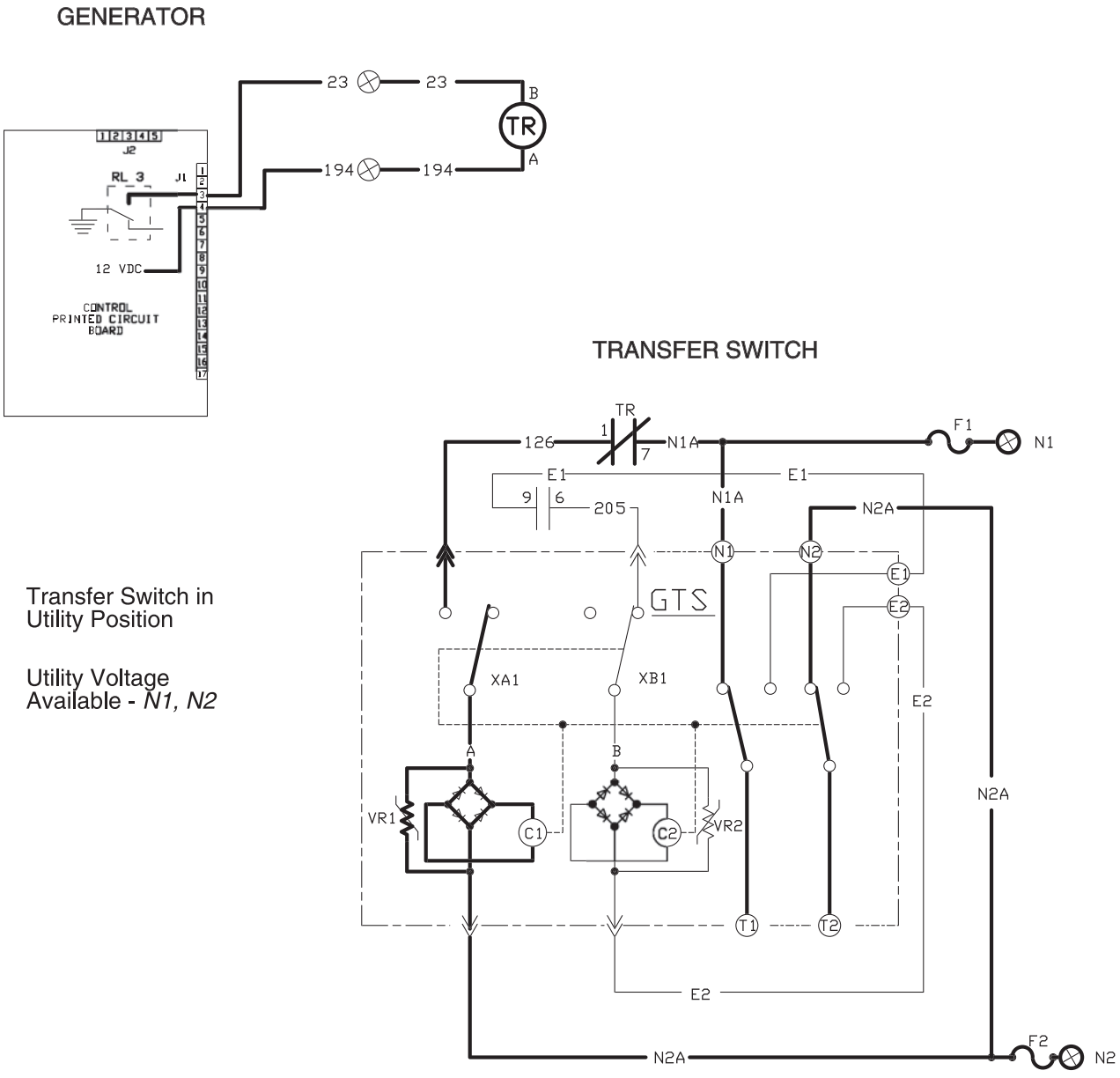


Figure 2. Utility Source Power Available

UTILITY SOURCE VOLTAGE FAILURE

If utility source voltage should drop below a preset value, the generator circuit board will sense the dropout. That circuit board will then initiate generator cranking and startup after a time delay circuit times out.

Figure 3 is a schematic representation of the transfer switch with generator power available, waiting to transfer.

- Generator voltage available E1, E2.
- Circuit board action holding Wire 23 open to ground.
- Power available to standby coil C2, upon closure of TR, normally open contacts (9 & 6) will close and initiate a transfer.

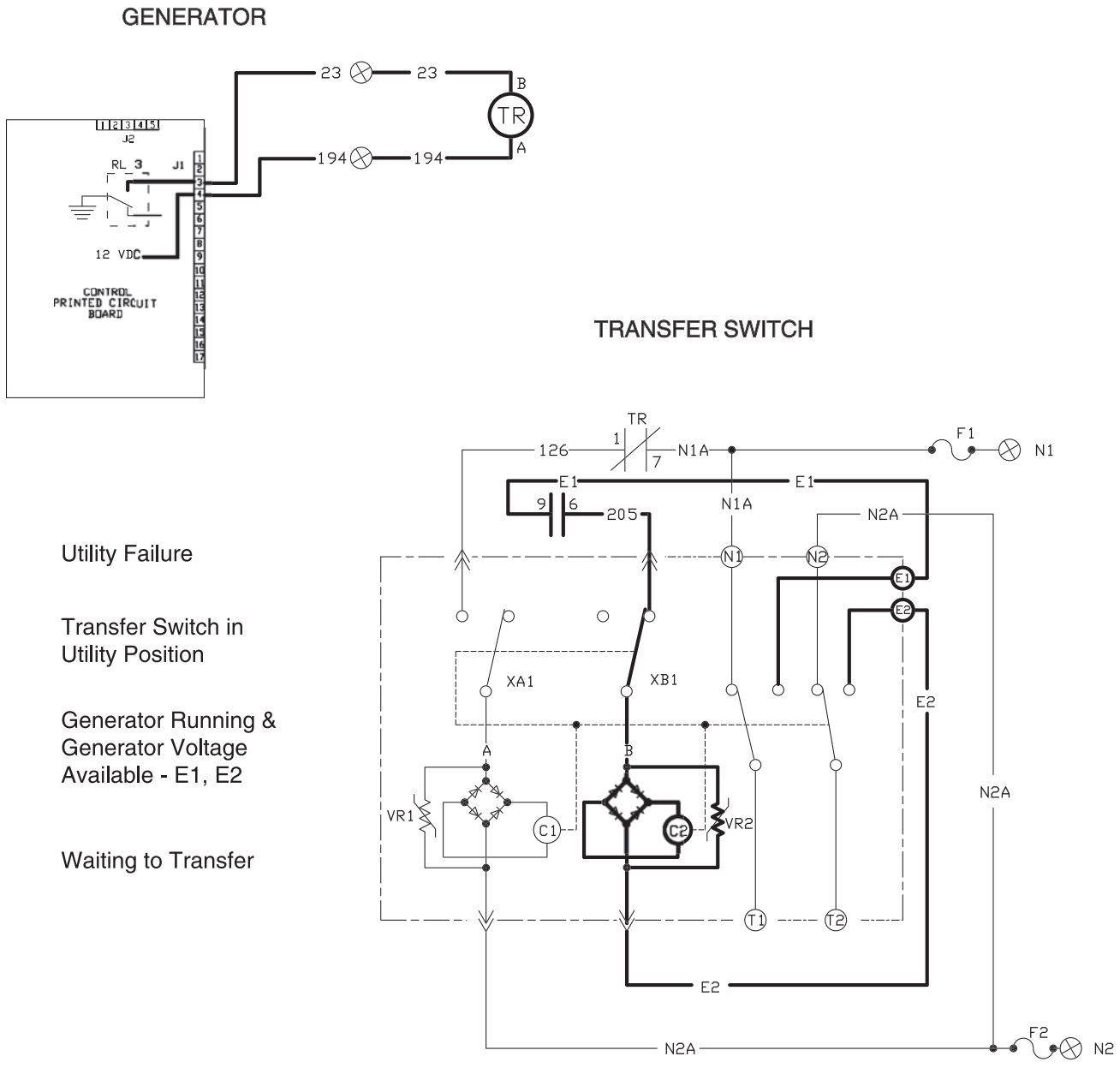
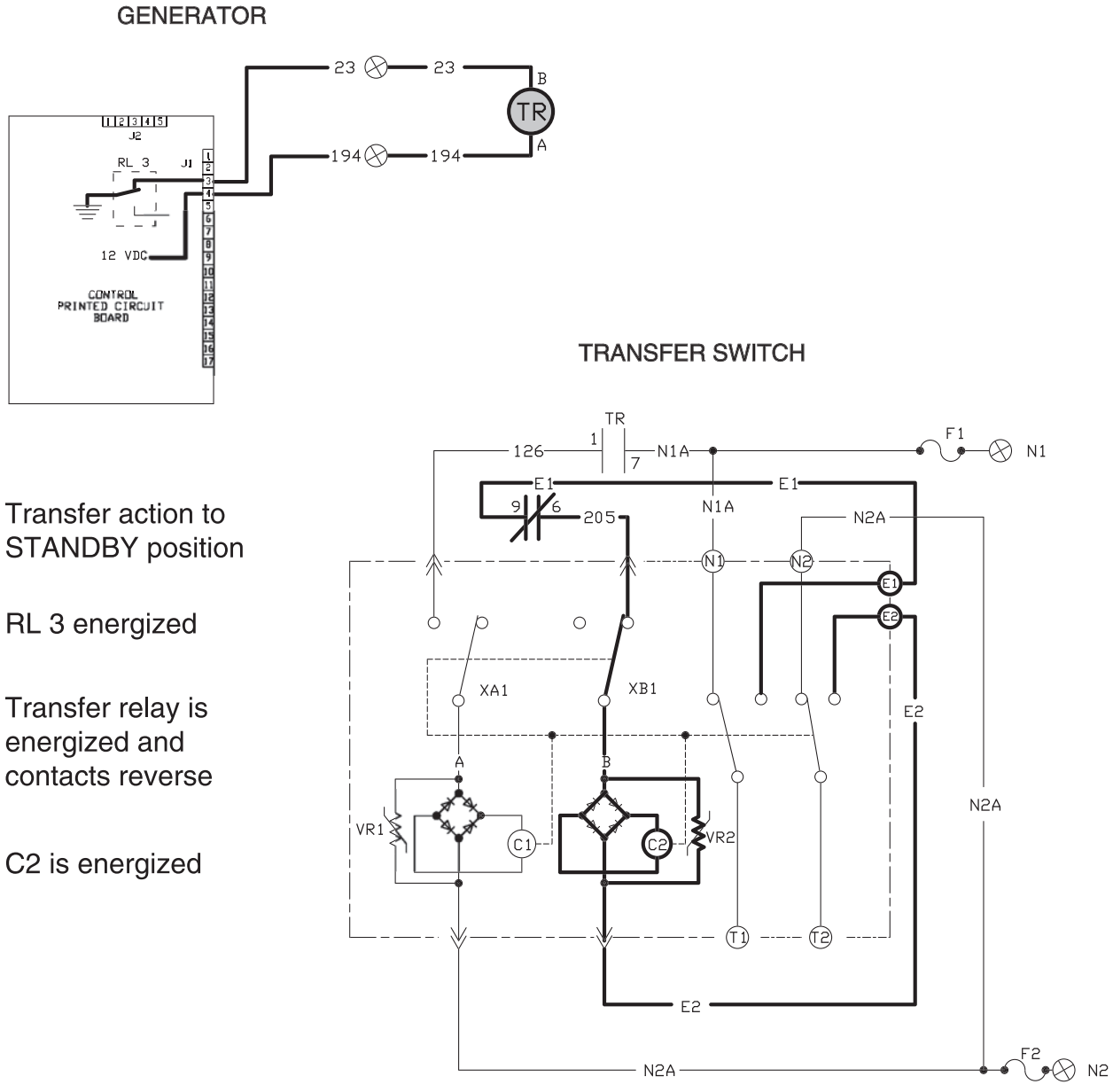


Figure 3. Generator Power Available, Waiting to Transfer.

TRANSFER TO STANDBY

The generator circuit board delivers 12 volts DC to the transfer relay, via terminal 194 and back to the circuit board via terminal 23. However, circuit board action holds the Wire 23 circuit open and the transfer relay remains de-energized. On generator startup, an "engine warm-up timer" on the generator circuit board starts timing. When that timer has timed out, circuit board action completes the Wire 23 circuit to ground. The transfer relay then energizes, its normally open contacts close, and standby source voltage is delivered to the standby closing coil via Wires E1 and E2, the transfer relay (TR) contacts, limit switch (XB1), Wire "B". and a bridge rectifier. The standby closing coil energizes and the main contacts actuate to their "Standby" side.



Transfer action to STANDBY position

RL 3 energized

Transfer relay is energized and contacts reverse

C2 is energized

Figure 4. Transfer Action to Standby Position

TRANSFER TO STANDBY

When the standby coil is energized it pulls the transfer switch mechanism to a overcenter position towards the standby power source side, the transfer switch mechanically snaps to the standby position. On closure of the main contacts to the standby power source side, limit switches XA1 and XB1 are mechanically actuated to "arm" the circuit for re- transfer to utility power source side.

Generator power from E1 and E2 is now connected to the customer load through T1 and T2.

Transfer action to STANDBY position

Transfer mechanism and limit switches change position

Generator is now powering load T1 & T2

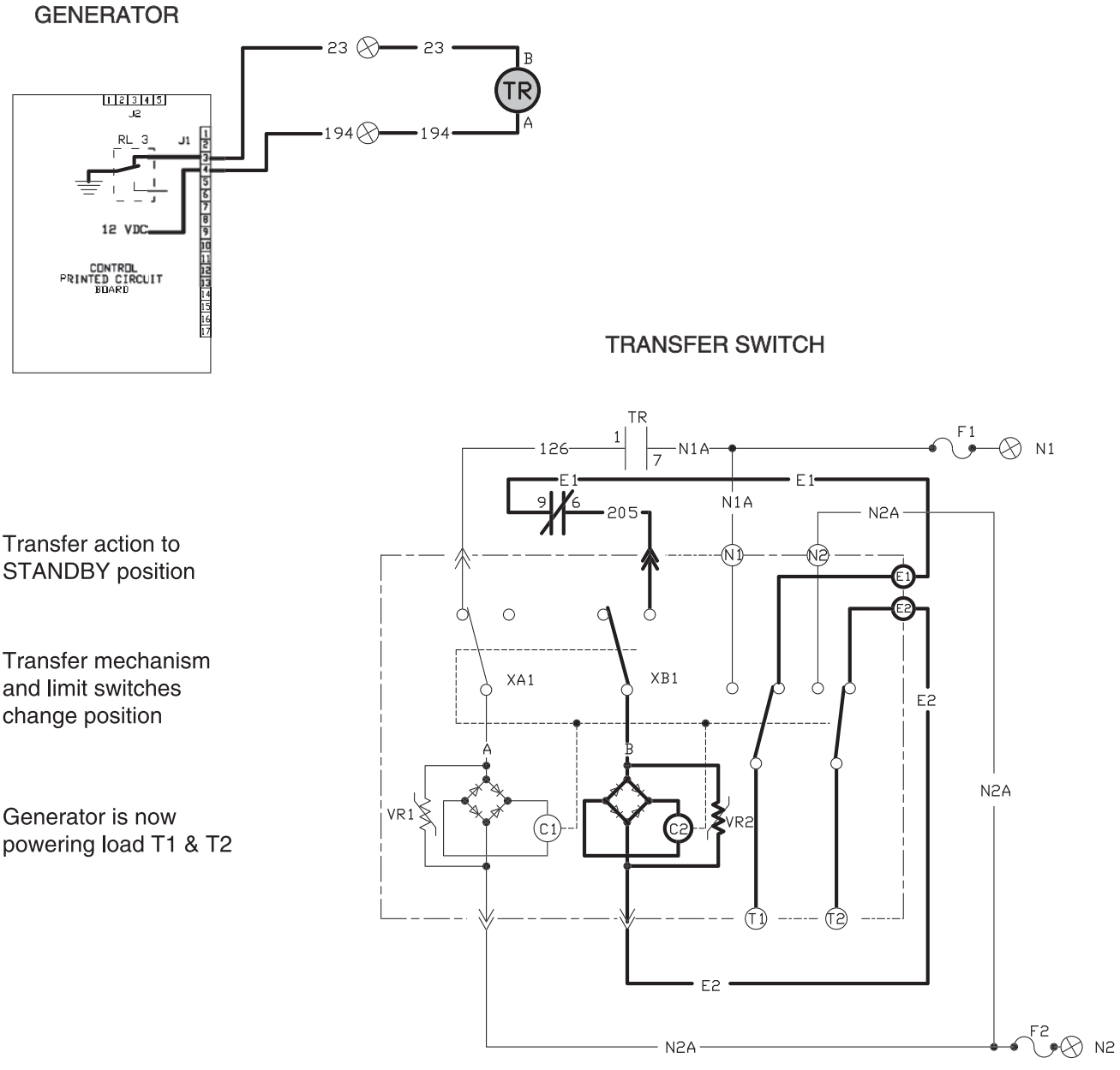


Figure 5. Generator Powering Load.

UTILITY RESTORED

Utility voltage is restored and is available to terminals N1 and N2. The utility voltage is sensed by the generators circuit board. If it is above a preset value for a preset time interval a transfer back to utility power will occur.

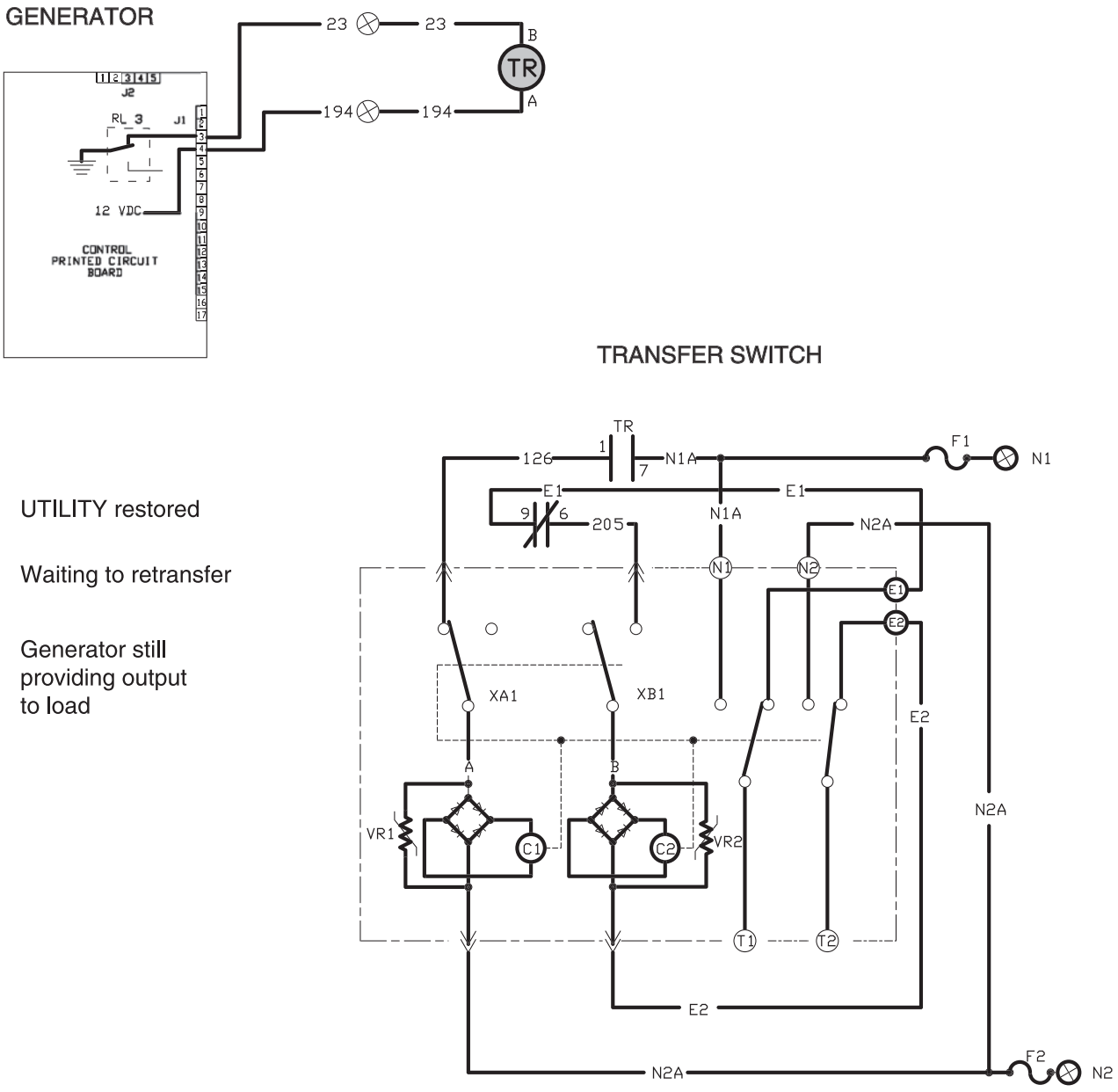


Figure 6. Utility Restored, Generator Still Providing Output to Load.

UTILITY RESTORED, TRANSFER SWITCH DE-ENERGIZED

After the preset time interval expires the circuit board will open the Wire 23 circuit to ground. The transfer relay de-energizes, it's normally closed contacts close, and utility source voltage is delivered to the utility closing coil (C1), via Wires N1A and N2A, closed Transfer Relay Contacts 1 and 7, and Limit Switch XA1.

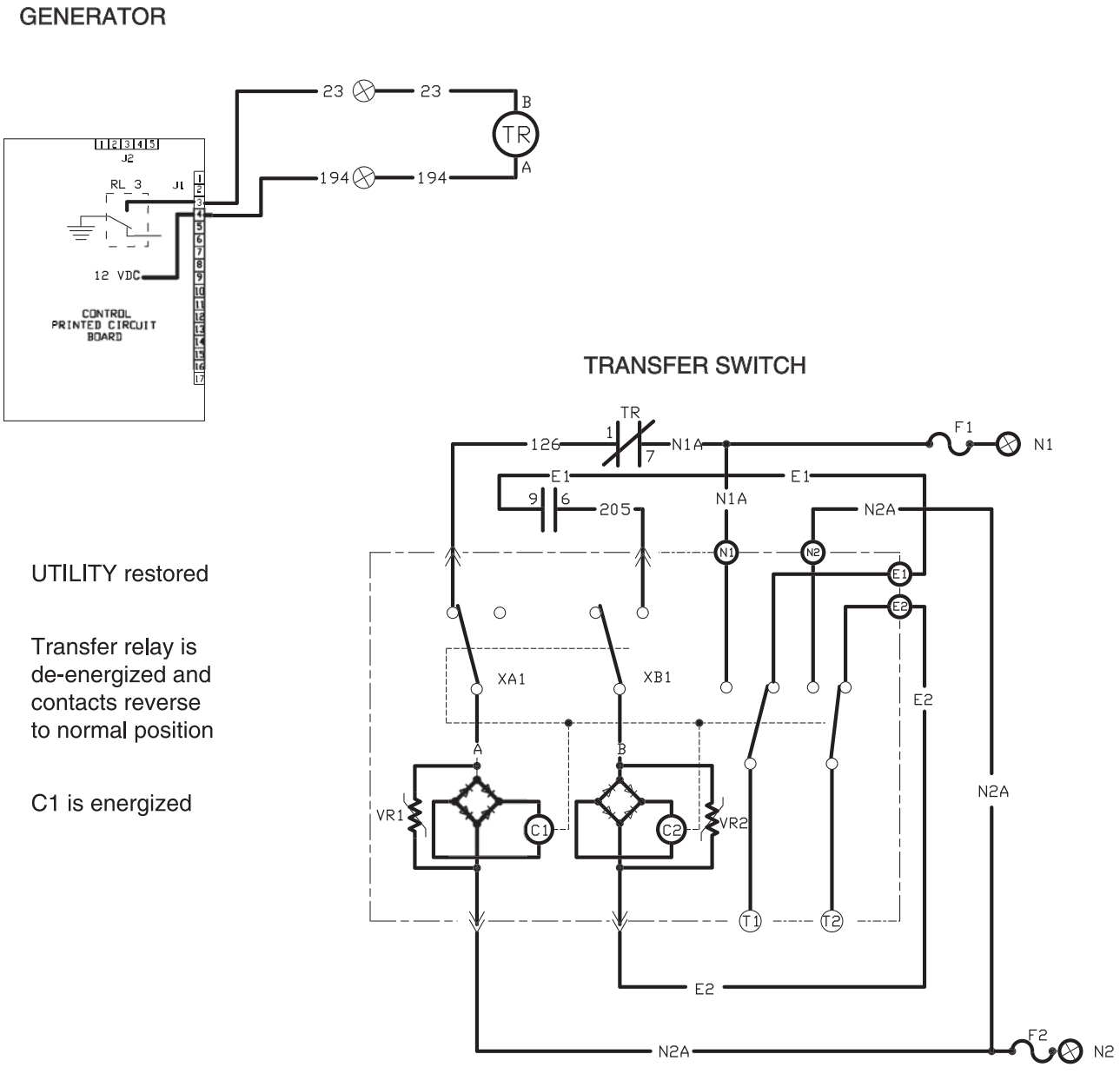


Figure 7. Utility Restored, Transfer Relay De-energized.

UTILITY RESTORED, RETRANSFER BACK TO UTILITY

As the utility coil pulls the transfer switch to an OVER CENTER position, the switch mechanically snaps to Utility. On closure of the main contacts to the utility power source side, Limit Switches XA1 and XB1 are mechanically actuated to "arm" the circuit for transfer to standby.

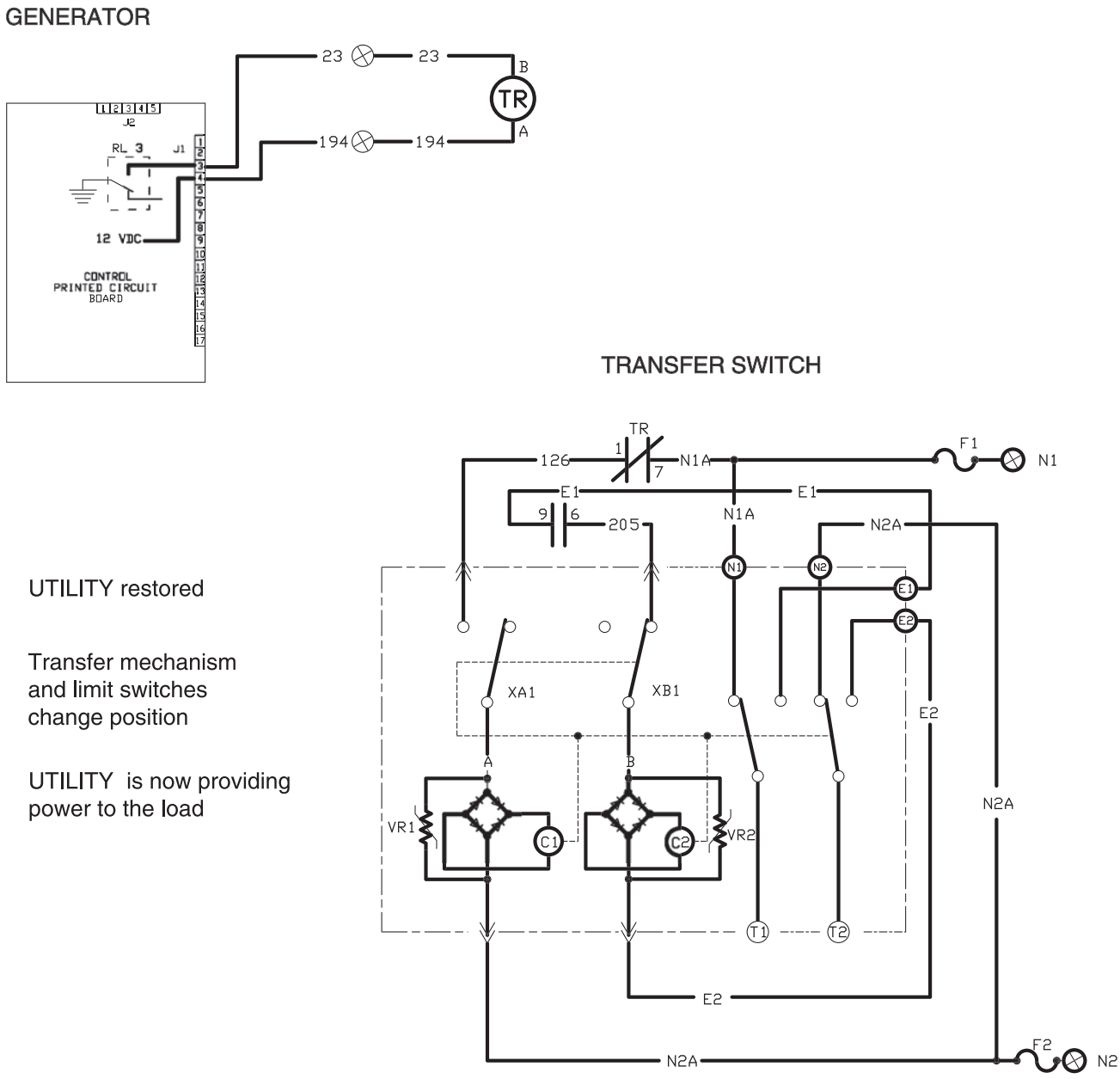


Figure 8. Utility Restored, Retransfer Back to Utility.

TRANSFER SWITCH IN UTILITY

When the transfer switch returns to the utility side, generator shutdown occurs after approximately one (1) minute.

Transfer switch in UTILITY position

UTILITY voltage available

Generator shuts down

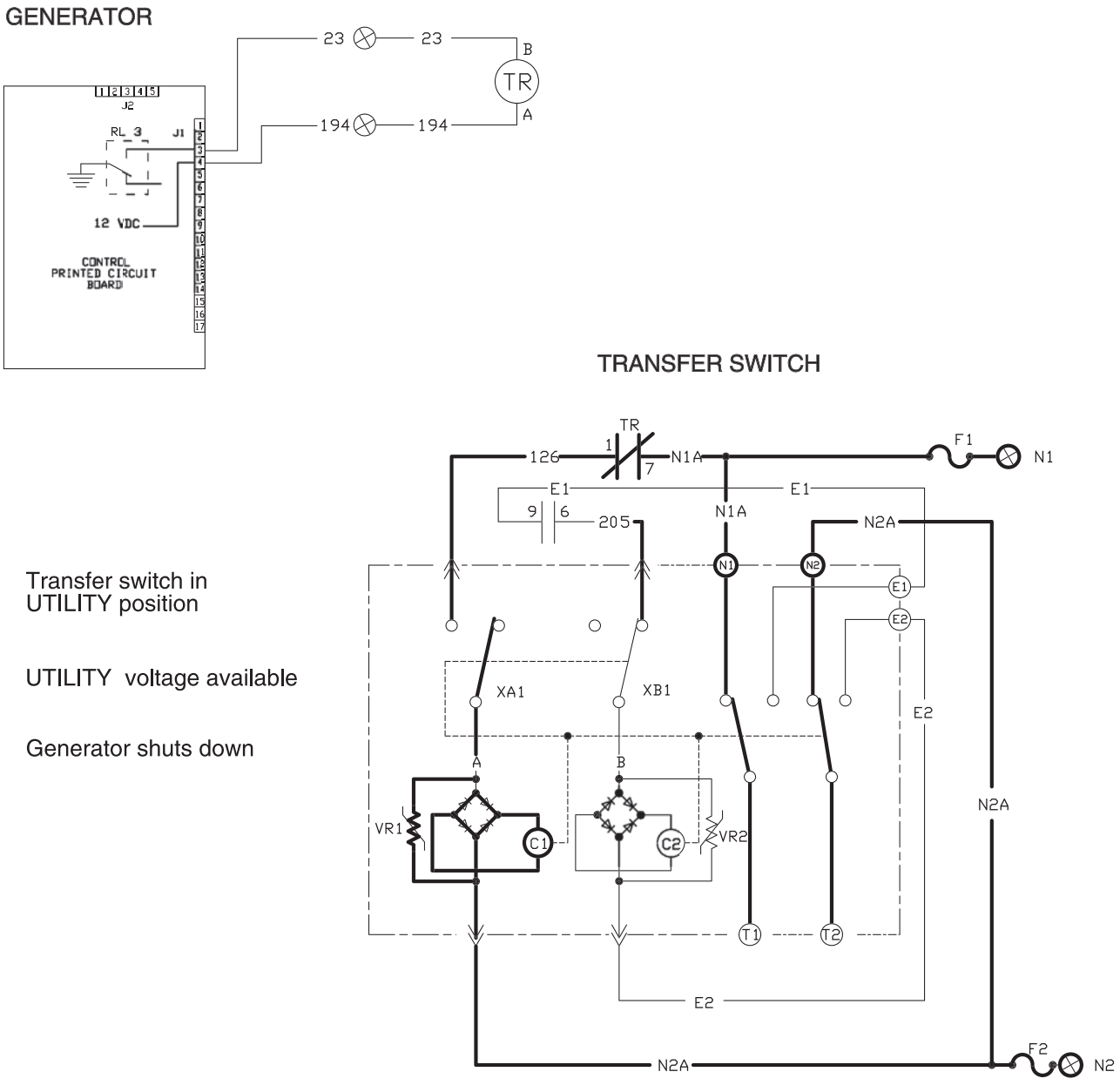


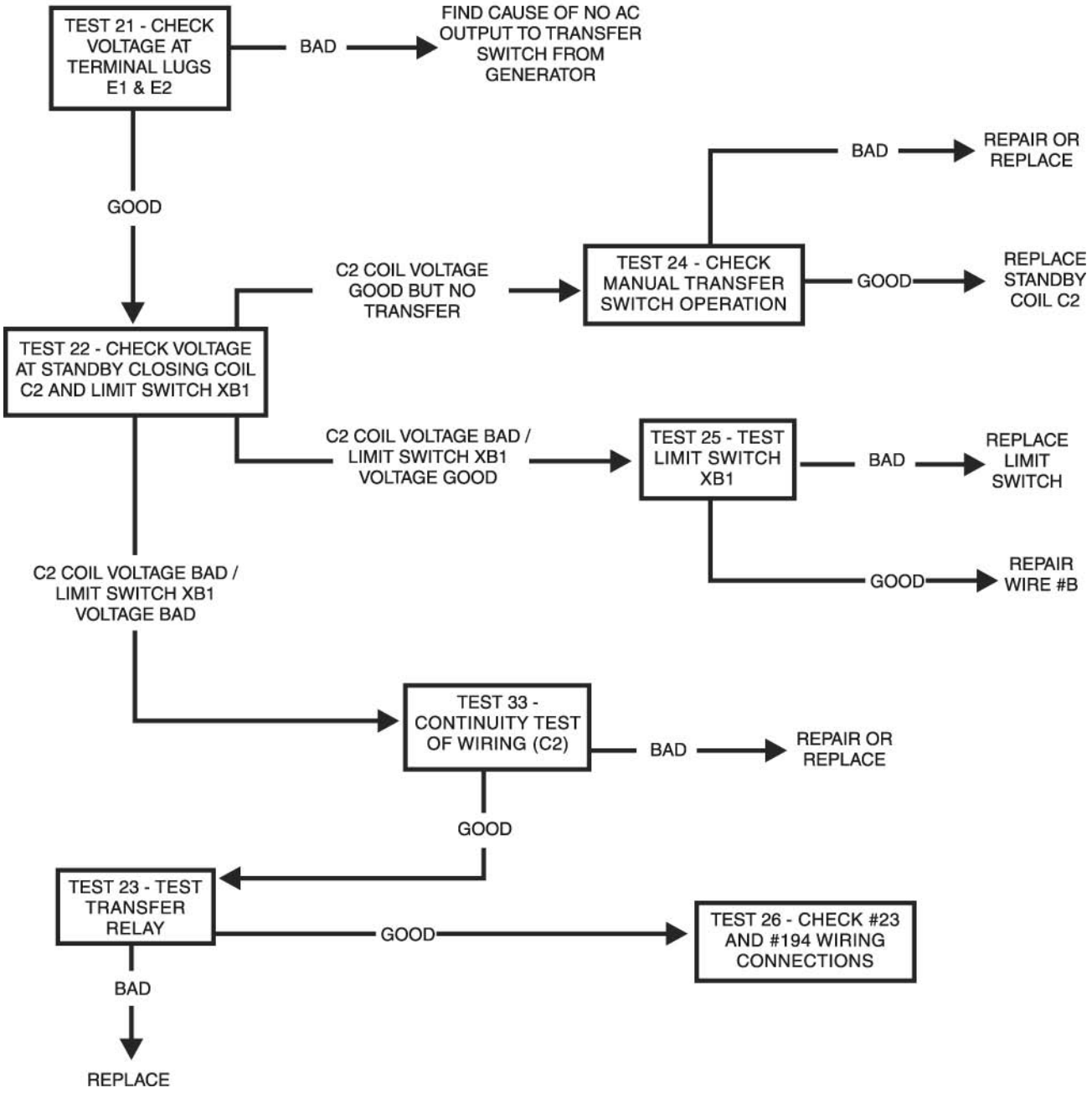
Figure 9. Transfer Switch in Utility.

INTRODUCTION TO TROUBLESHOOTING

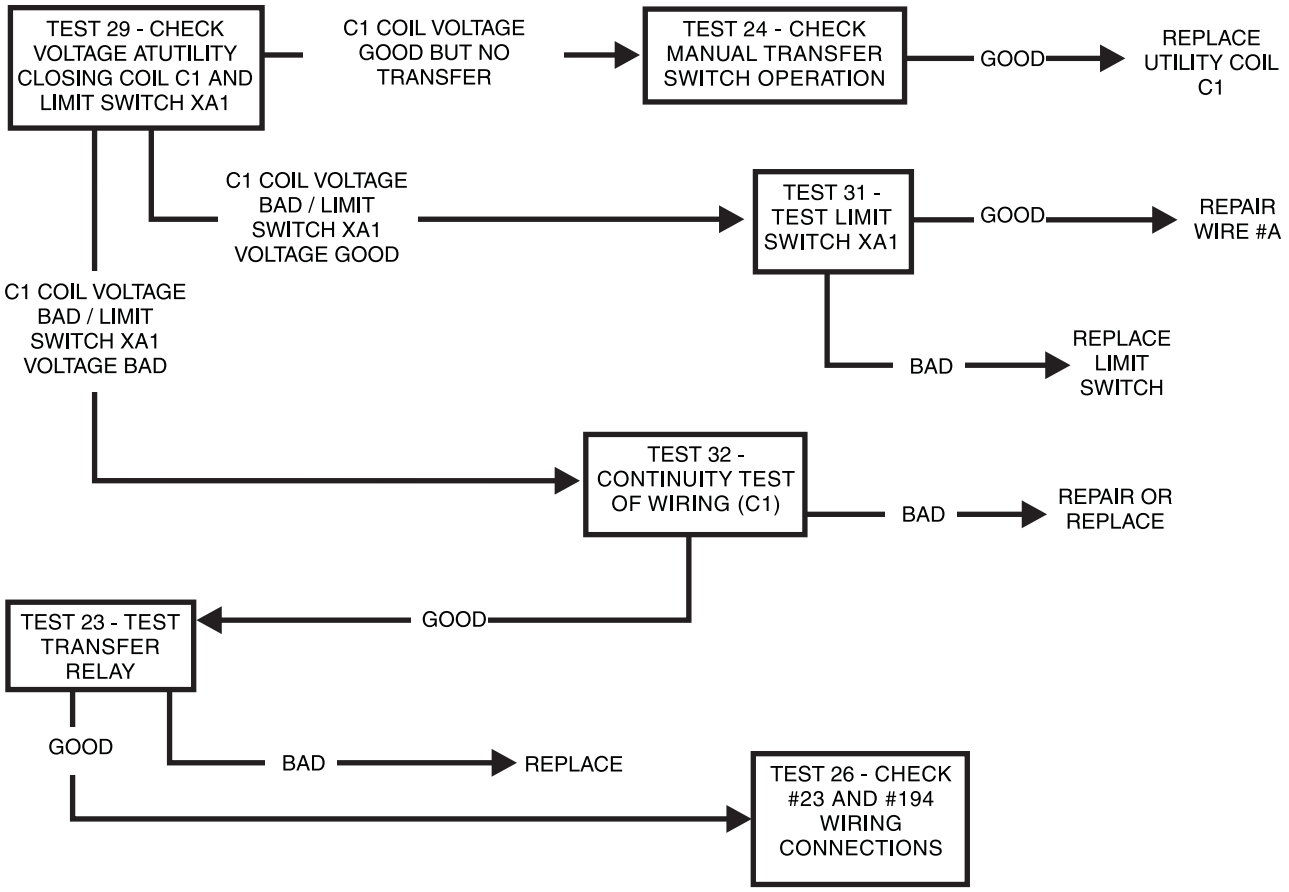
The first step in troubleshooting is to correctly identify the problem. Once that is done, the cause of the problem can be found by performing the tests in the appropriate flow chart.

Test numbers assigned in the flow charts are identical to test numbers in section 3.4, "Diagnostic Tests." Section 3.4 provides detailed instructions for performance of each test.

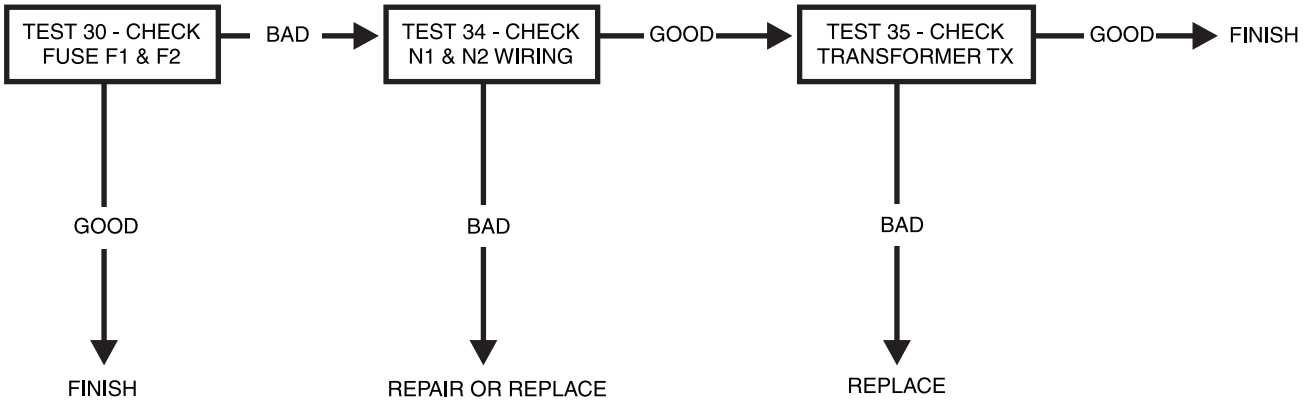
Problem 5 - In Automatic Mode, No Transfer to Standby


TEST 21 - CHECK VOLTAGE AT TERMINAL LUGS E1 & E2
BAD
FIND CAUSE OF NO AC OUTPUT TO TRANSFER SWITCH FROM GENERATOR
GOOD
BAD
REPAIR OR REPLACE
C2 COIL VOLTAGE GOOD BUT NO TRANSFER
TEST 24 - CHECK MANUAL TRANSFER SWITCH OPERATION
GOOD
REPLACE STANDBY COIL C2
TEST 22 - CHECK VOLTAGE AT STANDBY CLOSING COIL C2 AND LIMIT SWITCH XB1
C2 COIL VOLTAGE BAD / LIMIT SWITCH XB1 VOLTAGE GOOD
TEST 25 - TEST LIMIT SWITCH XB1
BAD
REPLACE LIMIT SWITCH
GOOD
REPAIR WIRE #B
C2 COIL VOLTAGE BAD / LIMIT SWITCH XB1 VOLTAGE BAD
TEST 33 - CONTINUITY TEST OF WIRING (C2)
BAD
REPAIR OR REPLACE
GOOD
TEST 23 - TEST TRANSFER RELAY
GOOD
TEST 26 - CHECK #23 AND #194 WIRING CONNECTIONS
BAD
REPLACE

Problem 6 - In Automatic Mode, Generator Starts When Loss of Utility Occurs, Generator Shuts Down When Utility Returns But There Is No Retransfer To Utility Power


TEST 29 - CHECK VOLTAGE ATUTILITY CLOSING COIL C1 AND LIMIT SWITCH XA1
C1 COIL VOLTAGE GOOD BUT NO TRANSFER
TEST 24 - CHECK MANUAL TRANSFER SWITCH OPERATION
GOOD
REPLACE UTILITY COIL C1
C1 COIL VOLTAGE BAD / LIMIT SWITCH XA1 VOLTAGE GOOD
TEST 31 - TEST LIMIT SWITCH XA1
GOOD
REPAIR WIRE #A
BAD
REPLACE LIMIT SWITCH
C1 COIL VOLTAGE BAD / LIMIT SWITCH XA1 VOLTAGE BAD
TEST 32 - CONTINUITY TEST OF WIRING (C1)
BAD
REPAIR OR REPLACE
GOOD
TEST 23 - TEST TRANSFER RELAY
GOOD
BAD
REPLACE
TEST 26 - CHECK #23 AND #194 WIRING CONNECTIONS

Problem 7 - Blown F1 or F2 Fuse



GENERAL

Test numbers in this section correspond to the numbered tests in Section 3.3, "Troubleshooting Flow Charts". When troubleshooting, first identify the problem. Then, perform the diagnostic tests in the sequence given in the flow charts.

TEST 21- CHECK VOLTAGE AT TERMINAL LUGS E1, E2

DISCUSSION:

In automatic mode, the standby closing coil (C2) must be energized by standby generator output if transfer to the "Standby" source is to occur. Transfer to "Standby" cannot occur unless that power supply is available to the transfer switch.

DANGER: BE CAREFUL! HIGH AND DANGEROUS VOLTAGES ARE PRESENT AT TERMINAL LUGS E1 AND E2 WHEN THE GENERATOR IS RUNNING. AVOID CONTACT WITH HIGH VOLTAGE TERMINALS OR DANGEROUS AND POSSIBLY LETHAL ELECTRICAL SHOCK MAY RESULT. DO NOT PERFORM THIS VOLTAGE TEST WHILE STANDING ON WET OR DAMP GROUND, WHILE BAREFOOT, OR WHILE HANDS OR FEET ARE WET.

PROCEDURE:

1. If the generator engine has started automatically (due to a utility power source outage) and is running, check the position of the generator main circuit breaker. The circuit breaker must be set to its "On" or "Closed" position. When you are sure the generator main circuit breaker is set to "On" or 'Closed", check the voltage at transfer mechanism terminal lugs E1 and E2 with an accurate AC voltmeter or with an accurate volt-ohm-milliammeter (VOM). The generator line-to line voltage should be indicated.
2. If the generator has been shut down, proceed as follows:
   a. On the generator control panel, set the Auto-Off-Manual switch to OFF.
   b. Turn OFF all power voltage supplies to the transfer switch. Both the utility and standby power supplies must be positively turned off before proceeding.
   c. Check the position of the transfer mechanism main contacts. The moveable LOAD contacts must be connected to the stationary UTILITY source contacts. If necessary, manually actuate the main contacts to the "Utility" power source side.
   d. Actuate the generator main line circuit breaker to its "On" or "Closed" position. The utility power supply to the transfer switch must be turned OFF.

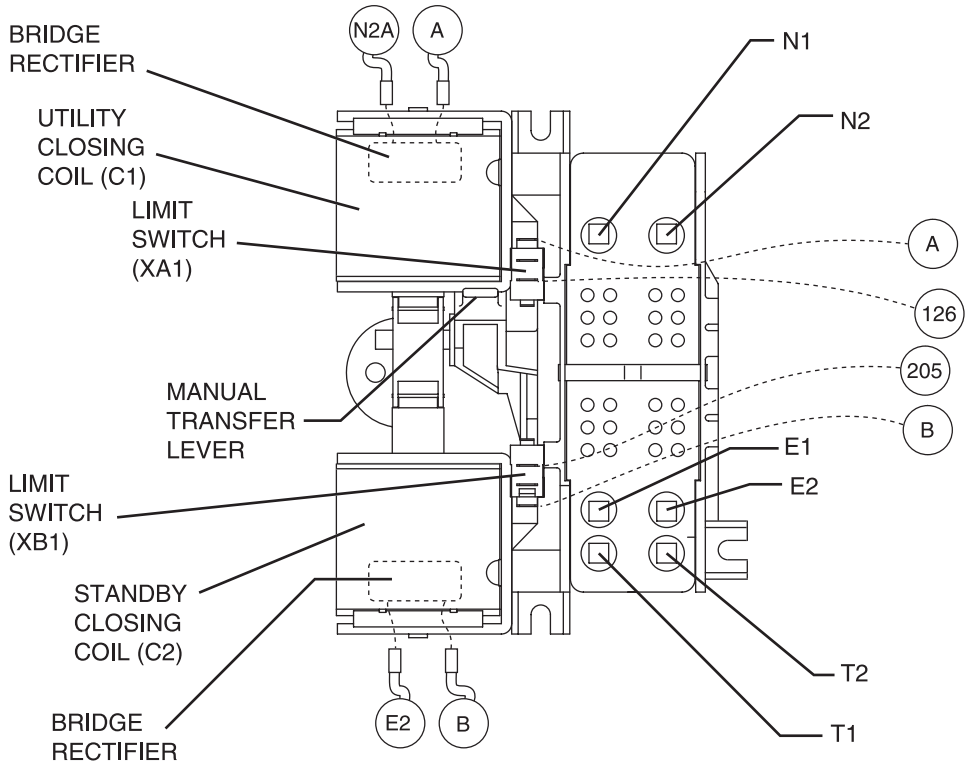


Figure 1. The "V-Type" Transfer Mechanism

e. Set the generator Auto-Off-Manual switch to AUTO.
   (1) The generator should crank and start.
   (2) When the generator starts, an "engine warm-up timer" should start timing. After about 15 seconds, the transfer relay should energize and transfer to the "Standby" source should occur.

f. If transfer to "Standby" does NOT occur, check the voltage across transfer switch terminal lugs E1 and E2. The generator line-to-line voltage should be indicated.

RESULTS:

1. If normal transfer to "Standby" occurs, discontinue tests.
2. If transfer to "Standby" does NOT occur and no voltage is indicated across terminal lugs E1/E2, determine why generator AC output has failed.
3. If transfer to "Standby" does NOT occur and voltage reading across terminal lugs E1/E2 is good, go on to Test 22.

TEST 22 - CHECK VOLTAGE AT STANDBY CLOSING COIL C2

DISCUSSION:

Standby source voltage is used to energize the standby closing coil and actuate the main contacts to their "Standby" source side. Standby source alternating current (AC) is changed to direct current (DC) by a bridge rectifier before reaching the closing coil. This test will determine if standby voltage is available to the closing coil.

If normal standby source voltage is available to the terminals of the standby closing coil but transfer to "Standby" does not occur, look for (a) binding or sticking in the transfer mechanism, (b) a defective coil, or (c) a bad bridge rectifier. The coil and the bridge rectifier must be replaced as a unit.

PROCEDURE:

1. Set the generator main line circuit breaker to the OFF or "Open" position.
2. Set the generators Auto-Off-Manual switch to the OFF position.
3. Set your VOM to measure AC voltage.

DANGER: BE CAREFUL! HIGH AND DANGEROUS VOLTAGES ARE PRESENT AT TERMINAL LUGS WHEN THE GENERATOR IS RUNNING. AVOID CONTACT WITH HIGH VOLTAGE TERMINALS OR DANGEROUS AND POSSIBLY LETHAL ELECTRICAL SHOCK MAY RESULT. DO NOT PERFORM THIS VOLTAGE TEST WHILE STANDING ON WET OR DAMP GROUND, WHILE BAREFOOT, OR WHILE HANDS OR FEET ARE WET.

4. Disconnect Wire E2 from the standby closing coil (C2). Connect one meter test Lead to Wire E2. Use a suitable and safe connection to this wire, such as an alligator clip that attaches to the meter test probe. Isolate this wire and test probe from any other potential source or ground.
5. If necessary, repeat Step 2 under "Procedure" of Test 21. The system must be in automatic operating mode, with engine running, and standby source voltage available to terminal lugs E1 and E2.
6. Locate on the standby closing coil the terminal that Wire B is connected to. (Figure 1, previous page). Connect the other meter test lead to this terminal. Generator line to line voltage should be indicated. If generator voltage is not indicated, proceed to Step 7.
7. With Wire E2 still connected to one test probe, connect the other meter test lead to Wire 205 on Limit Switch XB1(see Figure 1 on previous page). Generator line to line voltage should be measured.

RESULTS:

1. If generator line-to-line voltage is indicated in "Procedure, Step 6," but transfer does NOT occur, proceed to Test 24.
2. If generator line-to-line voltage is NOT indicated in "Procedure, Step 7," proceed to Test 33.
3. If generator line-to-line voltage is indicated in "Procedure, Step 7," proceed to Test 25.

TEST 23 - TEST TRANSFER RELAY TR

DISCUSSION:

In automatic operating mode, the transfer relay must be energized by circuit board action or standby source power will not be available to the standby closing coil. Without standby source power, the closing coil will remain de-energized and transfer to "Standby" will not occur. This test will determine if the transfer relay is functioning normally.

PROCEDURE:

1. See Figure 2. Disconnect all wires from the transfer relay, to prevent interaction.
2. Set a VOM to its "R x 1" scale and zero the meter.

3. Connect the VOM test leads across Relay Terminals 6 and 9 with the relay de-energized. The VOM should read infinity.

CONNECT VOM TEST LEADS ACROSS	DESIRED METER READING	
	ENERGIZED	DE-ENERGIZED
Terminals 6 and 9	Continuity	Infinity
Terminals 1 and 7	Infinity	Continuity

4. Using jumper wires, connect the positive (+) post of a 12 volt battery to relay Terminal "A" and the negative (-) battery post to Relay Terminal "B". The relay should energize and the VOM should read CONTINUITY.

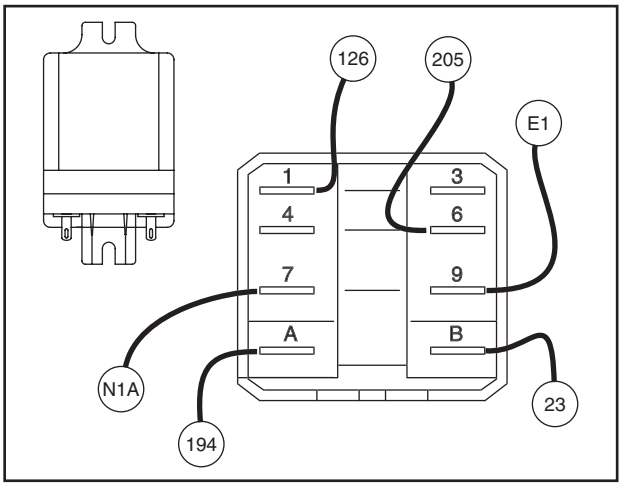


Figure 2. Transfer Relay Test Points

5. Now, connect the VOM test leads across Relay Terminals 1 and 7.
   a. Energize the relay and the meter should indicate infinity.
   b. De-energize the relay and the VOM should read CONTINUITY.

RESULTS:

1. Replace transfer relay if it is defective.
2. If transfer relay checks good go to Test 26.

TEST 24- CHECK MANUAL TRANSFER SWITCH OPERATION

DISCUSSION:

In automatic operating mode, when utility source voltage drops below a preset level, the engine should crank and start. On engine startup, an "engine warm-up timer" on the generator circuit board should start timing. When that timer has timed out (about 15 seconds), the transfer relay should energize to deliver utility source power to the standby closing coil terminals. If normal utility source voltage is available to the standby closing coil terminals, but transfer to Standby does not occur, the cause of the failure may be (a) a failed standby closing coil and/or bridge rectifier, or (b) a seized or sticking actuating coil or load contact. This test will help you evaluate whether any sticking or binding is present in the transfer mechanism.

PROCEDURE:

1. With the generator shut down, set the generator Auto-Off-Manual switch to OFF.
2. Set the generator main circuit breaker to OFF or "Open".
3. Turn off the utility power supply to the transfer switch,

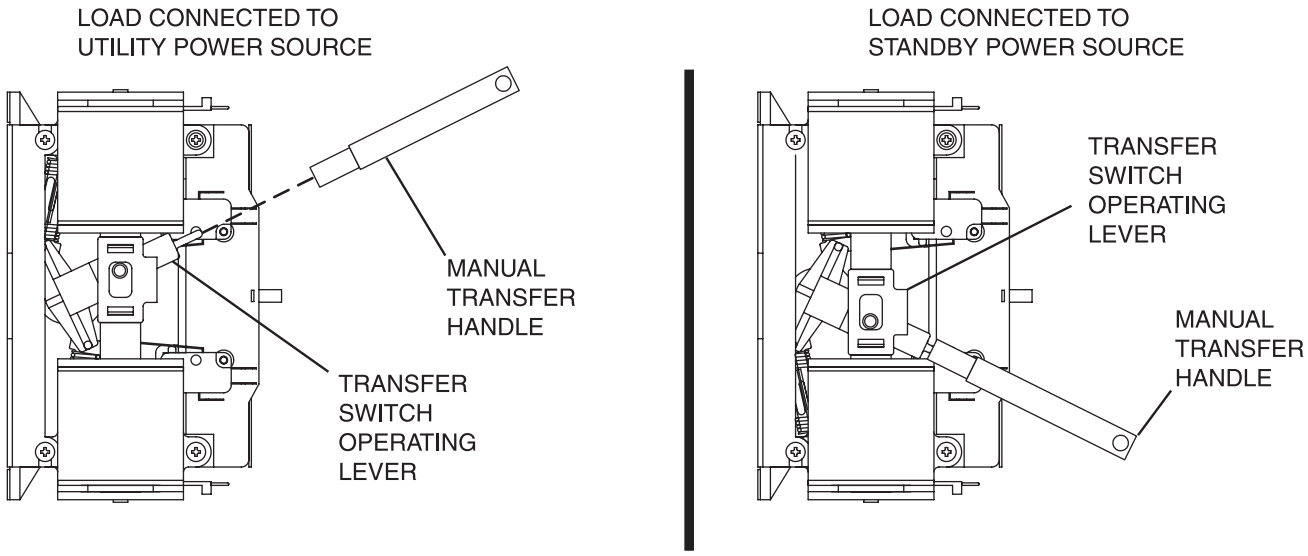

LOAD CONNECTED TO UTILITY POWER SOURCE
MANUAL TRANSFER HANDLE
TRANSFER SWITCH OPERATING LEVER
LOAD CONNECTED TO STANDBY POWER SOURCE
TRANSFER SWITCH OPERATING LEVER
MANUAL TRANSFER HANDLE

Figure 3. Manual Transfer Switch Operation

using whatever means provided (such as a utility source main line breaker).

DANGER: DO NOT ATTEMPT MANUAL TRANSFER SWITCH OPERATION UNTIL ALL POWER VOLTAGE SUPPLIES TO THE SWITCH HAVE BEEN POSITIVELY TURNED OFF. FAILURE TO TURN OFF ALL POWER VOLTAGE SUPPLIES MAY RESULT IN EXTREMELY HAZARDOUS AND POSSIBLY LETHAL ELECTRICAL SHOCK.

4. In the transfer switch enclosure, locate the manual transfer handle. Handle is retained in the enclosure with a wing nut. Remove the wing nut and handle.
5. See Figure 3. Insert the un-insulated end of the handle over the transfer switch operating lever.
   a. Move the transfer switch operating lever up to actuate the load contacts to the Utility position, i.e., load connected to the utility source.
   b. Actuate the operating lever down to move the load contacts against the standby contacts, i.e., load connected to the Standby source.
6. Repeat Step 5 several times. As the transfer switch operating lever is moved slight force should be needed until the lever reaches its center position. As the lever moves past its center position, an over-center spring should snap the moveable load contacts against the stationary Standby or Utility contacts.
7. Finally, actuate the main contacts to their Utility power source side, i.e., load contacts against the Utility contacts (upward movement of the operating lever).

RESULTS:

1. If there is no evidence of binding, sticking, excessive force required, replace the appropriate closing coil.
2. If evidence of sticking, binding, excessive force required to move main contacts, find cause of binding or sticking and repair or replace damaged part(s).

TEST 25- TEST LIMIT SWITCH XB1

DISCUSSION:

Standby power source voltage must be available to the standby closing coil in order for a transfer to standby action to occur. To deliver that source voltage to the coil, limit switch XB1 must be closed to the "Standby" power source side. If the limit switch did not get actuated or has failed open, the source voltage will not be available to the closing coil and transfer to "Standby" will not occur.

PROCEDURE:

With the generator shut down, the generator main circuit breaker turned OFF, and with the utility power supply to the transfer switch turned OFF, test limit switch XB1 as follows:

1. To prevent interaction, disconnect Wire 205 and Wire B from the limit switch terminals.
2. Set a VOM to its "R x 1" scale and zero the meter.
3. See Figure 1. Connect the VOM test probes across the two outer terminals from which the wires were disconnected.
4. Manually actuate the main contacts to their "Standby" position. The meter should read infinity.
5. Manually actuate the main contacts to their Utility position. The meter should read CONTINUITY.
6. Repeat Steps 4 and 5 several times and verify the VOM reading at each switch position.

RESULTS:

1. If Limit Switch XB1 fails the test, remove and replace the switch or adjust switch until it is actuated properly.
2. If limit switch is good, repair or replace Wire B between limit switch and Standby Coil (C2).

TEST 26 - CHECK 23 AND 194 WIRING/CONNECTIONS

DISCUSSION:

An open circuit in the transfer switch control wiring can prevent a transfer action from occurring. In the auto mode, the circuit board supplies +12 VDC to Wire 194. This DC voltage is supplied to the transfer relay (TR) at Terminal Location "A". The opposite side of the transfer relay (TR) coil (Terminal B) is connected to Wire 23. Positive 12VDC is present on this also. Circuit board action will allow current to flow through the circuit and the (TR) is energized.

PROCEDURE/RESULTS:

1. Set VOM to DC volts
2. Place generator Auto-Off-Manual switch to the AUTO position. Utility power should be present; the generator should not start.
3. Connect the negative (-) test lead to a suitable frame ground in the transfer switch.
4. Connect the positive (+) test lead to Wire 194 at the terminal strip in the transfer switch.
   a. If voltage is present, proceed to Step 5.
   b. If voltage is not present, proceed to Step 9.

5. Connect the positive (+) test lead to Wire 23 at the terminal strip in the transfer switch.
   a. If voltage is present, proceed to Step 6.
   b. If voltage is not present, repair wiring between terminal strip and transfer relay (TR).
6. Connect the negative (-) test lead to the ground lug in the generator control panel. Connect the positive (+) test lead to Wire 23 in the generator control panel at the interconnection terminals (ICT) or at the terminal strip.
   a. If voltage is present, proceed to Step 7.
   b. If voltage is not present, repair wiring between transfer switch and generator control panel.
7. Connect the positive (+) test lead to Wire 23 located in the J1 connector Pin Location 3, connected to the circuit board (see Figure 3, Section 4.1).
   a. If voltage is present, proceed to Step 8.
   b. If voltage is not present, repair wiring between (ICT and J1connector).
8. Turn off utility power to transfer switch, simulating a utility failure.
   a. Generator starts and transfer occurs, discontinue tests.
   b. Generator starts and transfer does not occur. With the generator running and utility off, ground Wire 23 in the control panel at interconnection terminals (ICT) or at the terminal strip. If transfer occurs replace circuit board.
9. Connect the negative (-) test lead to the ground lug in the generator control panel. Connect the positive (+) test lead to Wire 194 in the generator control panel at the interconnection terminals (ICT) or at the terminal strip.
   a. If the voltage is present, repair wiring between ICT (or terminal strip) and transfer switch
   b. If voltage is not present, proceed to Step 10.
10. Connect the positive (+) test lead to Wire 194 located in the J1 connector Pin Location 4, connected to the circuit board (see Figure 3, Section 4.1).
    a. If voltage is present, repair wiring between J1 connector and ICT (or terminal strip).
    b. If voltage is not present, replace circuit board.

TEST 27- CHECK VOLTAGE AT TERMINAL LUGS N1, N2

DISCUSSION:

If retransfer to the "Utility" power source side is to occur, utility source voltage must be available to terminal lugs N1 and N2 of the transfer mechanism. In addition, If that source voltage is not available to NI/N2 terminals, automatic startup and transfer to "Standby" will occur when the generator manual-off-auto switch is set to AUTO. This test will prove that "Utility" voltage is available to those terminals, or is not available. It is the first test in a series of tests that should be accomplished when (a) retransfer back to 'Utility" does not occur, or (b) startup and transfer occurs unnecessarily.

DANGER: PROCEED WITH CAUTION! HIGH AND DANGEROUS VOLTAGES ARE PRESENT AT TERMINAL LUGS N1/N2. CONTACT WITH HIGH VOLTAGE TERMINALS WILL RESULT IN DANGEROUS AND POSSIBLY LETHAL ELECTRICAL SHOCK. DO NOT ATTEMPT THIS TEST WHILE STANDING ON WET OR DAMP GROUND, WHILE BAREFOOT, OR WHILE HANDS OR FEET ARE WET.

PROCEDURE:

1. Make sure that all main line circuit breakers in the utility line to the transfer switch are “On” or “Closed.”
2. Test for utility source line-to-line voltage across terminal lugs N1 and N2 (see Figure 1). Normal utility source voltage should be indicated.

RESULTS:

1. If low or no voltage is indicated, find the cause of the problem and correct.
2. If normal utility source voltage is indicated, go on to Test 28.
3. For Problem 14 ONLY, if voltage is good, repair or replace Wire N1A/N2A between Transfer Switch Lugs N1/N2 and Fuse Holder connections.

TEST 28 - CHECK VOLTAGE AT UTILITY 1 AND UTILITY 2 TERMINALS

The Utility 1 and Utility 2 terminals in the transfer switch deliver utility voltage “sensing” to a circuit board. If voltage at the terminals is zero or low, standby generator startup and transfer to the “Standby” source will occur automatically as controlled by the circuit board. A zero or low voltage at these terminals will also prevent retransfer back to the “Utility” source.

PROCEDURE:

With utility source voltage available to terminal lugs N1 and N2, use an AC voltmeter or a VOM to test for utility source line-to-line voltage across terminal block

"Utility 1" and "Utility 2" terminals. Normal line-to-line utility source voltage should be indicated.

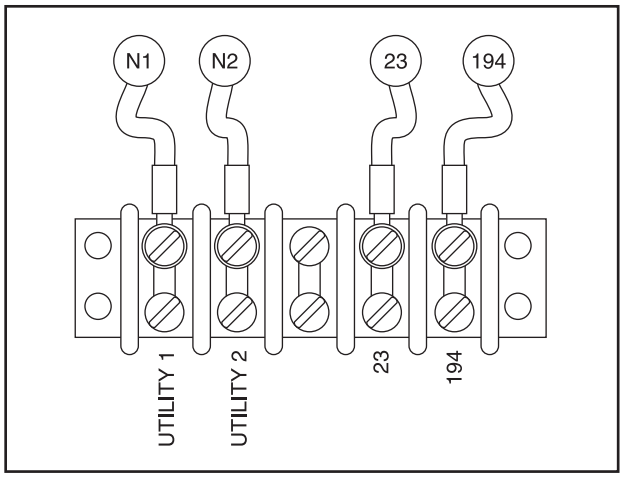


Figure 4. Transfer Switch Terminal Block

RESULTS:

1. If voltage reading across the "Utility I" and "Utility 2" terminals is zero, go to Test 30.
2. If voltage reading is good, go to Test 29.
3. For Problem 14 ONLY; if voltage is good, repair N1/N2 open wiring between Transfer Switch and Generator.

TEST 29- CHECK VOLTAGE AT UTILITY CLOSING COIL C1

DISCUSSION:

Utility source voltage is required to energize utility closing coil C1 and effect retransfer back to the "Utility" source. This voltage is delivered to the utility closing coil via Wires N1A and N2A, the transfer relay's normally-closed contacts (relay de-energized), Wire 126, Limit Switch XA1, and a bridge rectifier.

PROCEDURE:

1. On the generator control panel, set the Auto-Off-Manual switch to OFF.
2. Turn OFF the utility power supply to the transfer switch, using whatever means provided (such as a utility source main line circuit breaker).
3. Set the generator main line circuit breaker to its OFF or "Open" position.
4. Check the position of the transfer mechanism main contacts. The moveable load contacts must be connected to the stationary utility contacts. If necessary, manually actuate the main contacts to their "Utility source side (load connected to the "Utility' source).

DANGER: BE CAREFUL! HIGH AND DANGEROUS VOLTAGES ARE PRESENT AT TERMINAL LUGS WHEN THE GENERATOR IS RUNNING. AVOID CONTACT WITH HIGH VOLTAGE TERMINALS OR DANGEROUS AND POSSIBLY LETHAL ELECTRICAL SHOCK MAY RESULT. DO NOT PERFORM THIS VOLTAGE TEST WHILE STANDING ON WET OR DAMP GROUND, WHILE BAREFOOT, OR WHILE HANDS OR FEET ARE WET.

5. Disconnect Wire N2A from the utility closing coil (C1). Connect one meter test Lead to Wire N2A. Use a suitable and safe connection to this wire, such as an alligator clip that attaches to the meter test probe. Isolate this wire and test probe from any other potential source or ground.
6. Set the generator main line circuit breaker to its "On" or "Closed" position.
7. Set the generator Auto-Off-Manual switch to AUTO.
   a. The generator should crank and start.
   b. About 15 seconds after engine startup, the transfer relay should energize and transfer to the 'Standby" source should occur.
8. When you are certain that transfer to "Standby" has occurred, turn ON the utility power supply to the transfer switch. After a 15 seconds, retransfer back to the "Utility" source should occur.
9. Locate on the utility closing coil the terminal that Wire A is connected to (see Figure 1, Section 3.4). Connect the other meter test lead to this terminal. Generator line to line voltage should be indicated. If generator voltage is not indicated, proceed to Step 10.
10. With Wire N2A still connected to one test probe, connect the other meter test lead to Wire 126 on Limit Switch XA1 (see Figure 1, Section 3.4). Generator line to line voltage should be measured.

RESULTS:

1. In Step 7, if the generator does not crank or start, refer to Part 4, "DC Control".
2. In Step 7, if transfer to the "Standby" source does not occur, go to Problem 1.
3. In Step 9, if normal utility source line-to-line voltage is indicated but retransfer back to "Utility" does not occur, go to Test 24.
4. If normal utility source line-to-line voltage is not indicated in Step 9, but is indicated in Step 10, proceed to Test 31.

5. If normal utility source line-to-line voltage is NOT indicated in Step 8, and is NOT indicated in Step 9, proceed to Test 32.

TEST 30 - CHECK FUSES F1 AND F2

DISCUSSION:

Fuses F1 and F2 are connected in series with the Utility 1 and Utility 2 circuits, respectively. A blown fuse will open the applicable circuit and will result in (a) generator startup and transfer to "Standby", or (b) failure to retransfer back to the utility source.

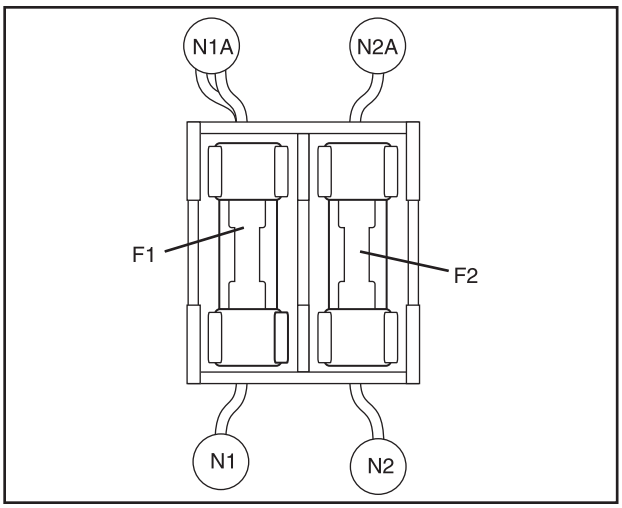


Figure 5. Fuse Holder and Fuses

PROCEDURE:

1. On the generator panel, set the Auto-Off-Manual switch to OFF.
2. Turn off the utility power supply to the transfer switch, using whatever means provided.
3. Remove fuses F1 and F2 from the fuse holder (see Figure 5).
4. Inspect and test fuses for blown condition.

RESULTS:

1. Replace blown fuse(s) and proceed to Test 34.
2. For Problem 7 (DC Control section), go to Test 27.

TEST 31 - TEST LIMIT SWITCH XA1

DISCUSSION:

When the transfer switch main contacts are actuated to their "Utility" position, limit switch XA1 should be mechanically actuated to its open position. On transfer to the "Standby" position, the limit switch should actuate to its closed position. If the switch does not actuate to its closed position, retransfer back to "Utility" will not occur.

PROCEDURE:

1. With the standby generator shut down, set its Auto-Off-Manual switch to OFF.
2. Turn OFF the utility power supply to the transfer switch, using whatever means provided.
3. To prevent interaction, disconnect Wire 126 and Wire "A" from the limit switch terminals.
4. Set a VOM to its "R x 1 " scale and zero the meter.
5. Connect the VOM test leads across the two limit switch terminals from which Wires A and 126 were removed.
6. Manually actuate the main contacts to their "Standby" position. The VOM should indicate CONTINUITY.
7. Manually actuate the main contacts to their "Utility" position. The VOM should read infinity.

RESULTS:

Replace limit switch XA1 if it checks bad.

NOTE: Problems with transfer switch operation can also be caused by (a) defective wiring between the generator and transfer switch, or (b) a defective component in the generator circuit board. See Part 4, "DC Control".

TEST 32 - CONTINUITY TEST OF WIRING (C1)

DISCUSSION:

This test will ensure that all control wiring has continuity.

1. Set the Auto-Off-Manual switch to the OFF position.
2. Turn the generator main circuit breaker to the off position.
3. Turn off the utility power supply to the transfer switch using whatever means provided. (Such as utility source main line circuit breaker).
4. Set your VOM to the "R x 1" scale.
5. Disconnect Wire N2A from the Utility Coil C1 and connect one test lead to it. Connect the other test lead to terminal lug N2 of the transfer switch. CONTINUITY should be read. Reconnect Wire N2A.
6. Disconnect Wire 126 from transfer relay (TR) and connect one test lead to it. Connect the other test lead to limit switch XA1 bottom terminal Wire 126. CONTINUITY should be read. Reconnect Wire 126.

7. Disconnect Wire N1A from transfer relay (TR) terminal and connect one test lead to it. Connect the other test lead to F1 top fuse terminal Wire N1A. CONTINUITY should be read. Reconnect Wire N1A.

RESULTS:

Repair any defective wiring that does not read CONTINUITY. If wiring tests good, proceed to Test 23.

TEST 33 - CONTINUITY TEST OF WIRING (C2)

DISCUSSION:

This test will ensure that all control wiring has continuity.

1. See Test 32, Step 1
2. See Test 32, Step 2
3. See Test 32, Step 3
4. See Test 32, Step 4
5. Disconnect Wire E2 from the standby coil (C2) and connect one test lead to it. Connect the other test lead to Terminal Lug E2 of the transfer switch. CONTINUITY should be read. Reconnect Wire E2.
6. Disconnect Wire 205 from transfer relay (TR) Terminal 6 and connect one test lead to it. Connect the other test lead to limit switch XB1 top terminal Wire 205. CONTINUITY should be read. Reconnect Wire 205.
7. Disconnect Wire E1 from Transfer Relay (TR) Terminal 9 and connect one test lead to it. Connect the other test lead to terminal lug E1 of the transfer switch. CONTINUITY should be read. Reconnect Wire E1.

RESULTS:

Repair any defective wiring that does not read CONTINUITY. If wiring tests good, proceed to Test 23.

TEST 34 - CHECK N1 AND N2 WIRING

DISCUSSION:

A shorted Wire N1 or N2 to ground can cause fuse F1 or F2 to blow.

PROCEDURE:

1. On the generator panel, set the Auto-Off-Manual switch to OFF.
2. Turn off the utility power supply to the transfer switch, using whatever means are provided.
3. Remove fuses F1 and F2 from the fuse holder (see Figure 5).
4. Remove the generator control panel cover. Disconnect wire N1 and wire N2 from the interconnection terminal in the control panel, or the terminal strip.
5. Set your VOM to the 'R x 1" scale. Connect the positive meter test lead to wire N1.
   a. Connect the negative meter lead to the ground lug. Infinity should be measured.
   b. Connect the negative meter lead to Wire 23 at ICT or terminal strip. Infinity should be measured.
   c. Connect the negative meter lead to Wire 194 at ICT or terminal strip. Infinity should be measured.
   d. Connect the negative meter lead to the neutral connection. Infinity should be measured.
6. Set your VOM to the 'R x 1" scale. Connect the positive meter test lead to wire N2.
   a. Connect the negative meter lead to the ground lug. Infinity should be measured.
   b. Connect the negative meter lead to Wire 23 at ICT or terminal strip. Infinity should be measured.
   c. Connect the negative meter lead to Wire No. 194 at ICT or terminal strip. Infinity should be measured.
   d. Connect the negative meter lead to the neutral connection. Infinity should be measured.
7. Disconnect wire N1 and wire N2 from transformer TX.
8. Connect one test lead to wire N1 removed in step 7, and the other test lead to the ground terminal. INFINITY should be measured.
9. Connect one test lead to wire N2 removed in step 7, and the other test lead to the ground terminal. INFINITY should be measured.
10. If no short is indicated in steps 5 through 9, proceed with steps 11 through 15. If a short is indicated in steps 5 through 9, repair shorted wiring.
11. Reconnect wires N1 and N2 to the interconnection terminal or terminal strip.
12. Replace fuses F1 and F2 in the fuse holder.
13. Turn on the utility power supply to the transfer switch using whatever means is provided.
14. Set VOM to measure AC voltage. Connect one test lead to wire N1 and the other test lead to wire N2. Utility line to line voltage should be measured.
15. Turn off the utility power supply to the transfer switch using whatever means is provided.

RESULTS:

If a short is indicated in steps 5 through 9, repair wiring and re-test. If utility line to line voltage is measured in Step 14, proceed to Test 35.

TEST 35 - CHECK TRANSFORMER (TX)

DISCUSSION:

The transformer is a step down type and has two functions. It supplies approximately 16VAC to the control board for utility sensing. It also supplies approximately 16 VAC to the battery charger when utility is available for trickle charge. A shorted transformer can result in fuse F1 or F2 blowing.

PROCEDURE:

1. On the generator panel, set the Auto-Off-manual switch to OFF.
2. Turn off the utility power supply to the transfer switch, using whatever means is provided.
3. See Figure 6. Disconnect Wires N1, N2, 224, 225, 224A, 225A from transformer (TX).
4. Set a VOM to the "R x 1" scale.
5. Connect one test lead to TX terminal 1. Connect the other test lead to TX terminal 5. Approximately 38.5 ohms should be measured
6. Connect one test lead to TX terminal 10. Connect the other test lead to TX terminal 9. Approximately 1.5 ohms should be measured.
7. Connect one test lead tot TX terminal 7. Connect the other test lead to TX terminal 6. Approximately 0.3 ohms should be measured.
8. Connect one test lead to TX terminal 1. Connect the other test lead to the transformer case. INFINITY should be measured.
9. Connect one test lead to TX terminal 7. Connect the other test lead to the transformer case. INFINITY should be measured.
10. Connect one test lead to TX terminal 9. Connect the other test lead to the transformer case. INFINITY should be measured.
11. Connect one test lead to TX terminal 1. Connect the other test lead to TX terminal 10. INFINITY should be measured.
12. Connect one test lead to TX terminal 1. Connect the other test lead to TX terminal 7. INFINITY should be measured.
13. Connect one test lead to TX terminal 10. Connect the other test lead t TX terminal 7. INFINITY should be measured.

RESULTS:

For steps 5, 6, and 7, replace transformer if an open is indicated, or if the resistance value indicated is zero. If the resistance value is not within the approximate range, proceed to test 65.

For steps 8 through 13, replace the transformer if it fails any of these steps.

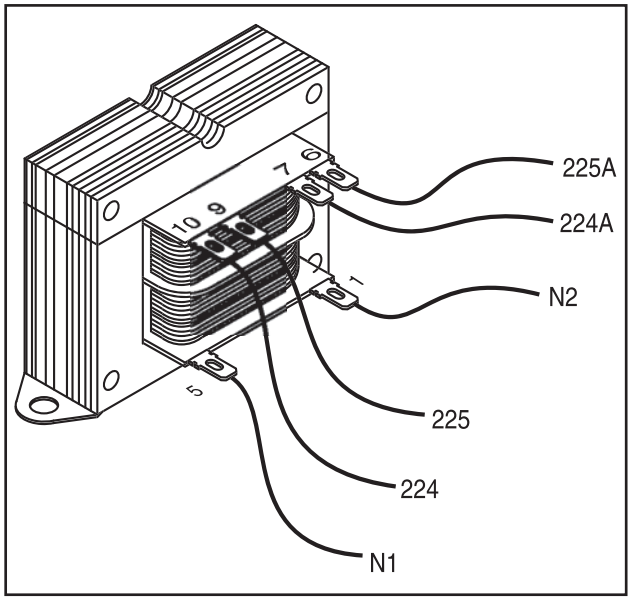


Figure 6. Transformer (TX)

PART 4
DC CONTROL

Air-cooled, Prepackaged Automatic Standby Generators

Models:
6 kW NG, 7 kW LP
12 kW NG, 12 kW LP
13 kW NG, 15 kW LP

TABLE OF CONTENTS

PART	TITLE
4.1	Description and Components
4.2	Operational Analysis
4.3	Troubleshooting Flow Charts
4.4	Diagnostic Tests

GENERAL

This section will familiarize the reader with the various components that make up the DC control system.

Major DC control system components that will be covered include the following:

o A Terminal Strip / Interconnection Terminal

- A Transformer (TX)
- A Circuit Board.
- An Auto-Off-Manual Switch.
- A 15 Amp Fuse.
- A 5 Amp Fuse.

TERMINAL STRIP / INTERCONNECTION TERMINAL

The terminals of this terminal strip are connected to identically numbered terminals on a prepackaged transfer switch terminal board. The terminal board connects the transfer switch to the circuit board and transformer.

The terminal board provides the following connection points:

A. Utility 1 and Utility 2

1. Connect to identically marked terminals on a prepackaged transfer switch terminal board.
2. The circuit delivers "Utility" power source voltage to the transformer (TX) located in the control panel assembly.

B. 23 and 194

1. Connect to identically numbered terminals on the terminal board of the prepackaged transfer switch.
2. This circuit connects the circuit board to the transfer relay coil in the prepackaged transfer switch.

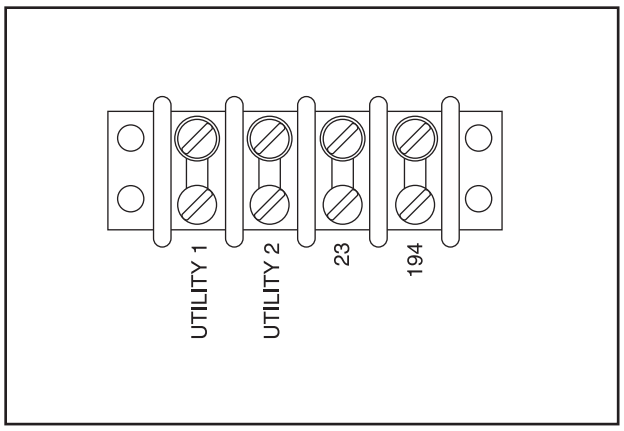


Figure 1. Terminal Board

TRANSFORMER (TX)

The control panel assembly's transformer is a step-down type. The line-to-line voltage from the Utility 1/Utility 2 terminals is delivered to the transformer's primary winding. Transformer action then induces a reduced voltage (about 12 to 16 volts) into both secondary transformer windings. Reduced voltage from one secondary winding is delivered to the circuit board as "Utility" source sensing voltage. Reduced voltage from the other secondary winding is delivered to the battery charger for trickle charging.

- If the Utility sensing voltage drops below a preset value, circuit board action will initiate automatic generator startup and transfer to the "Standby" source side.

The sensing transformer is shown in Figure 2, both pictorially and schematically.

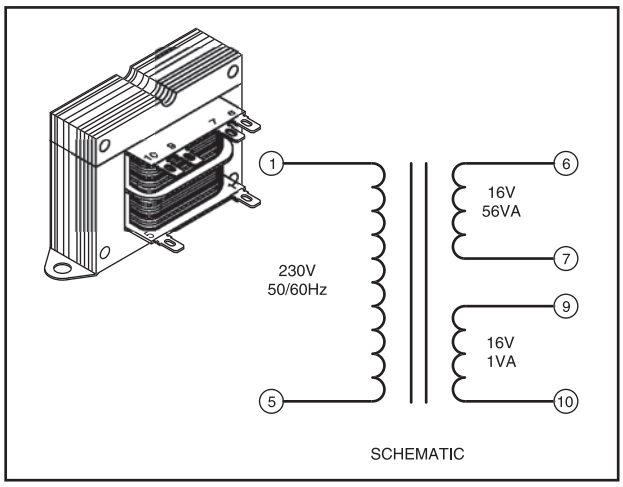


Figure 2. The Transformer

CIRCUIT BOARD

The circuit board controls all standby electric system operations including (a) engine startup, (b) engine running, (c) automatic transfer, (d) automatic retransfer, and (e) engine shutdown. In addition, the circuit board performs the following functions:

- Delivers "field boost" current to the generator rotor windings (see "Field Boost Circuit" in Section 2.2).
- Starts and "exercises" the generator once every seven days.
- Provides automatic engine shutdown in the event of low oil pressure, high oil temperature, or overspeed.

A 17-pin and a 5-pin connector are used to interconnect the circuit board with the various circuits of the DC systems. Connector pin numbers, associated wires and circuit functions are listed in the CHART on the next page.

J1 PIN	WIRE	CIRCUIT FUNCTION
1	4	Field boost current to rotor (about 9-10 volts DC).
2	86	Low oil pressure shutdown. Automatic shutdown occurs when Wire 85 is grounded by loss of oil pressure to the LOP.
3	23	Switched to ground for Transfer Relay (TR) operation.
4	194	12 VDC output from the circuit board for transfer relay, present in AUTO or MANUAL operation.
5	56	Energized (12 volts DC) by circuit board's crank relay (K1) to crank the engine.
6	18	Engine shutdown. Circuit is grounded by circuit board action to ground the engine
7	14	12 VDC output for engine run condition. Used for fuel solenoid (FS), battery charge relay (BCR), and hourmeter if equipped.
8	66A	AC input to the board for crank terminate and overspeed protection.
9	239	B+ input when SW1 is in the MANUAL position.
10	15A	B+ input into the board for source voltage when SW1 is in the AUTO or MANUAL position.
11	17	B+ output to SW1 for manual start operation.
12	15	12VDC source voltage for the circuit board. Also runs timer for exerciser.
13	0	Common ground.
14	225	Transformer reduced "Utility" source sensing voltage.
15	224	Transformer reduced "Utility" source sensing voltage.
16		NOT USED
17		NOT USED
J2 PIN	**WIRE**	**CIRCUIT FUNCTION**
1		NOT USED
2	85	High temperature oil engine safety.
3	351	Input set exercise. Signal to ground to set.
4		NOT USED
5		NOT USED

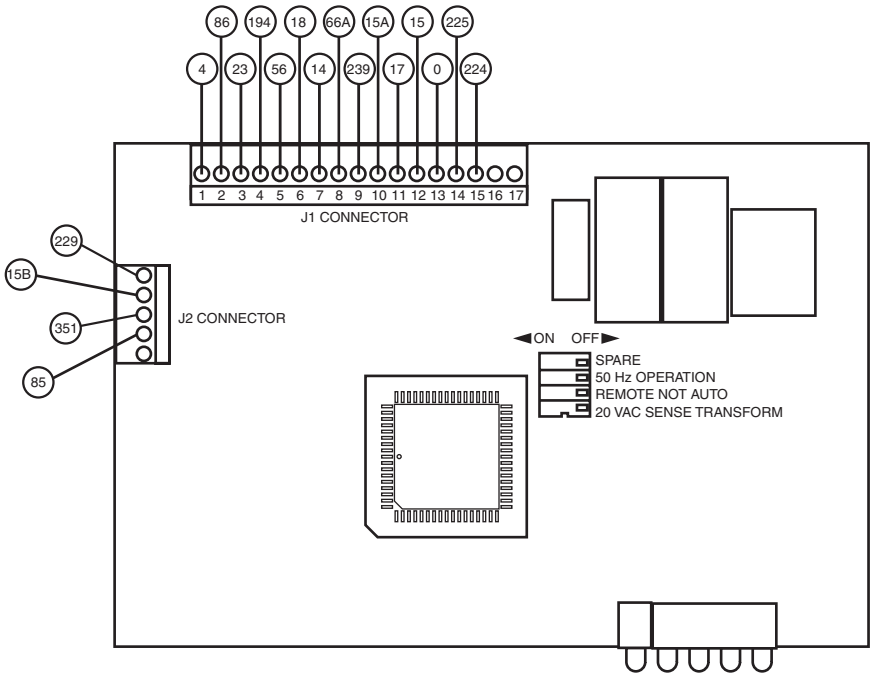


Figure 3. Circuit Board

The circuit board mounts a crank relay (K1) and a run relay (K2, see Figure 4). Crank relay (K1) is energized by circuit board action during both manual and automatic startup to crank the engine. Cranking is accomplished in crank-rest cycles, with the first cycle being 15 seconds on and 15 seconds off. After the first crank-rest cycle, the remaining cycles will be in equal 7-9 second durations. This cyclic cranking action continues until either (a) the engine starts, or (b) approximately 90 seconds of the crank-rest cycles have elapsed.

The run relay is energized by circuit board action at the same time as the crank relay, to energize and open a fuel solenoid valve.

DANGER: THE GENERATOR ENGINE WILL CRANK AND START WHEN THE 7-DAY EXERCISER SWITCH IS ACTUATED. THE UNIT WILL ALSO CRANK AND START EVERY 7 DAYS THEREAFTER, ON THE DAY AND AT THE TIME OF DAY THE SWITCH WAS ACTUATED.

AUTO-OFF-MANUAL SWITCH

This 3-position switch permits the operator to (a) select fully automatic operation, (b) start the generator manually, or (c) stop the engine and prevent automatic startup. Switch terminals are shown pictorially and schematically in Figure 5, below.

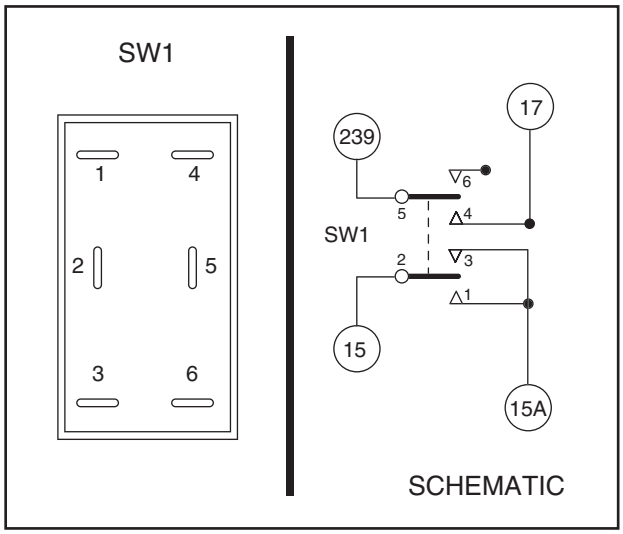


Figure 4. The Auto-Off-Manual Switch

15 AMP FUSE

This fuse protects the circuit board against excessive current. If the fuse has blown, engine cranking and operation will not be possible. Should fuse replacement become necessary, use only an identical 15-amp replacement fuse.

7.5 AMP FUSE

This fuse protects the 12 VDC accessory socket against overload. If the fuse element has melted open due to an overload, the 12 VDC socket will not provide power to accessories. Should fuse replacement become necessary, use only an identical 7.5 amp replacement fuse.

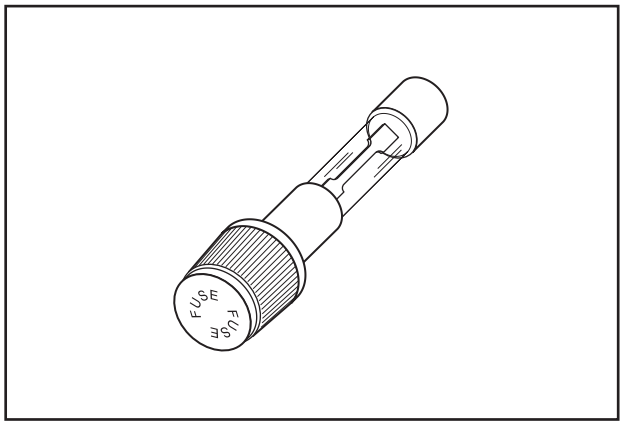


Figure 5. 15 Amp Fuse

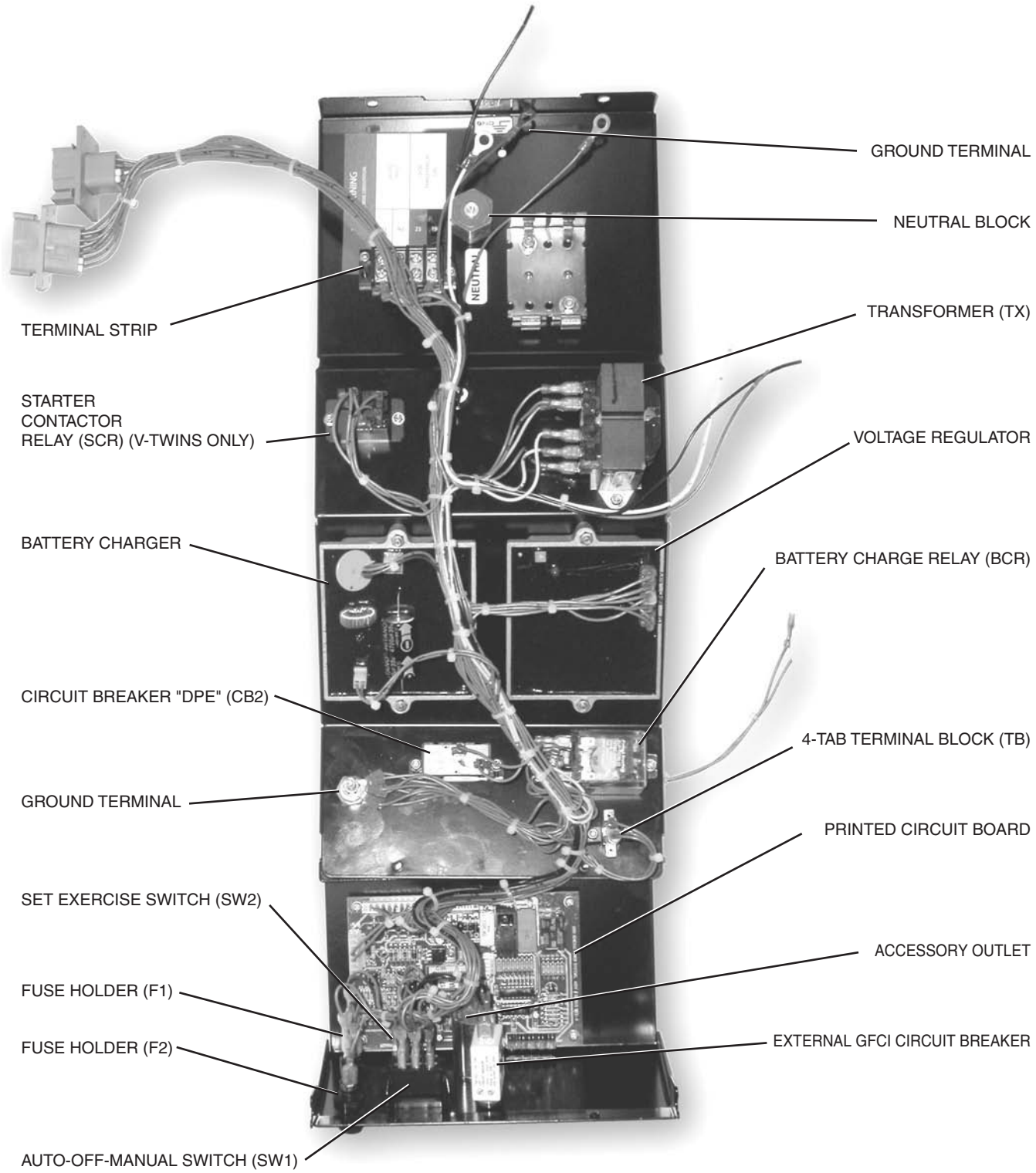


Figure 6. Control Panel Component Identification

INTRODUCTION

This "Operational Analysis" is intended to familiarize the service technician with the operation of the DC control system on prepackaged units with air-cooled engine. A thorough understanding of how the system works is essential to sound and logical troubleshooting. The DC control system illustrations on the following pages include a "V-Type" prepackaged transfer switch.

UTILITY SOURCE VOLTAGE AVAILABLE

See Figure 1, above. The circuit condition with the Auto-Off-Manual switch set to AUTO and with "Utility" source power available can be briefly described as follows:

- "Utility" source voltage is available to transfer switch terminal lugs N1/N2. With the transfer switch main contacts at their "Utility" side, this source voltage is available to terminal lugs T1/T2 and to the "Load" circuits.

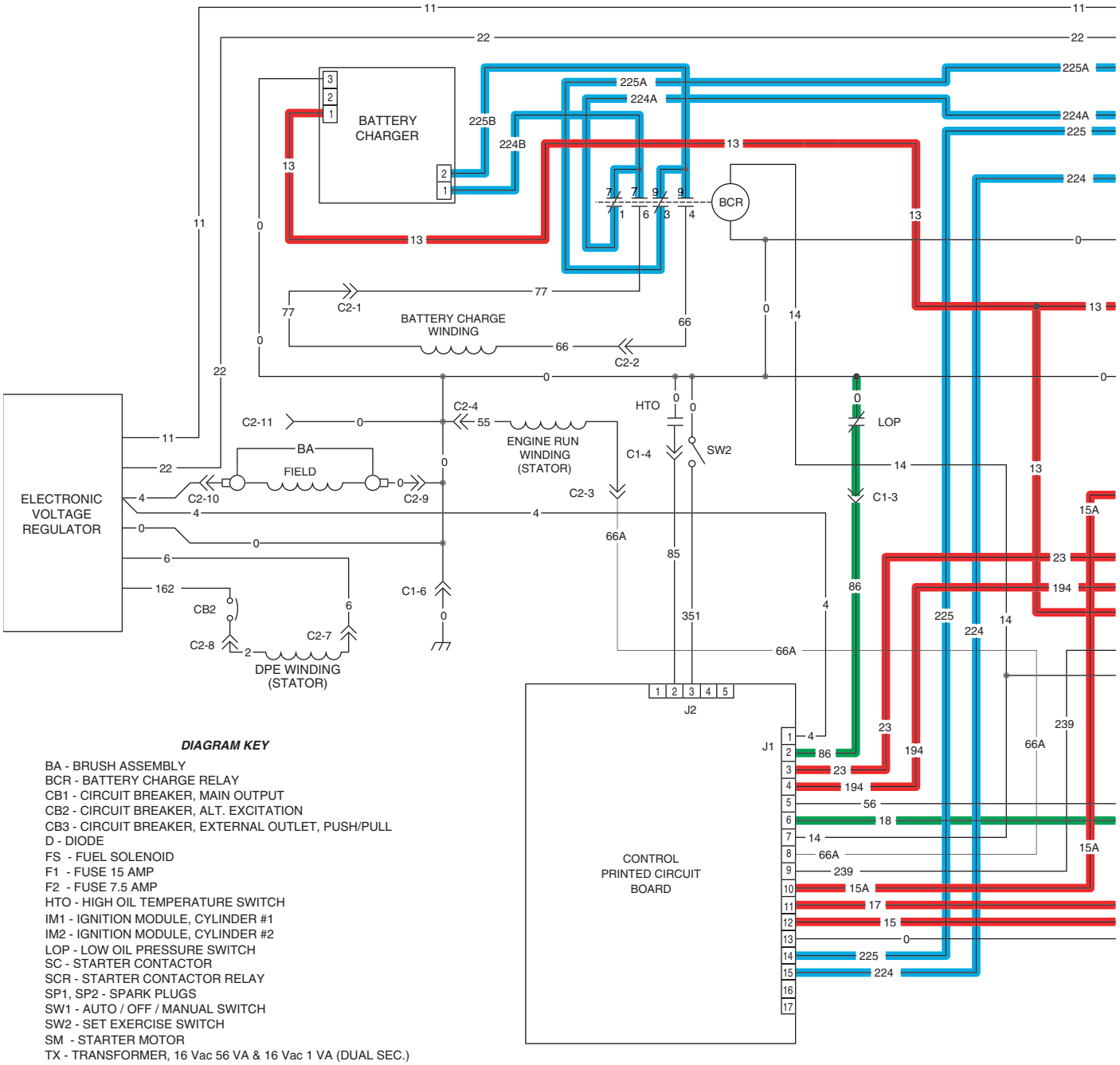


DIAGRAM KEY

BA - BRUSH ASSEMBLY
BCR - BATTERY CHARGE RELAY
CB1 - CIRCUIT BREAKER, MAIN OUTPUT
CB2 - CIRCUIT BREAKER, ALT. EXCITATION
CB3 - CIRCUIT BREAKER, EXTERNAL OUTLET, PUSH/PULL
D - DIODE
FS - FUEL SOLENOID
F1 - FUSE 15 AMP
F2 - FUSE 7.5 AMP
HTO - HIGH OIL TEMPERATURE SWITCH
IM1 - IGNITION MODULE, CYLINDER #1
IM2 - IGNITION MODULE, CYLINDER #2
LOP - LOW OIL PRESSURE SWITCH
SC - STARTER CONTACTOR
SCR - STARTER CONTACTOR RELAY
SP1, SP2 - SPARK PLUGS
SW1 - AUTO / OFF / MANUAL SWITCH
SW2 - SET EXERCISE SWITCH
SM - STARTER MOTOR
TX - TRANSFORMER, 16 Vac 56 VA & 16 Vac 1 VA (DUAL SEC.)

= 12 VDC ALWAYS PRESENT
= AC VOLTAGE
= GROUND FOR CONTROL PURPOSES
= 12 VDC DURING CRANKING ONLY
= 12 VDC DURING ENGINE RUN CONDITION

- "Utility" voltage is delivered to the primary winding of a sensing transformer (TX), via transfer switch wires N1/N2, fuses F1/F2, connected wiring, and Control Panel "Utility 1/Utility 2" terminals. A resultant voltage (about 16 volts AC) is induced into the transformer secondary windings and then delivered to the circuit board via Wires 224/225. The circuit board uses this reduced "Utility" voltage as sensing voltage. Wires 224A/225A supply 16 VAC to the battery charger.
- Battery output is delivered to the circuit board with the Auto-Off-Manual switch (SW1) set to AUTO, as shown.

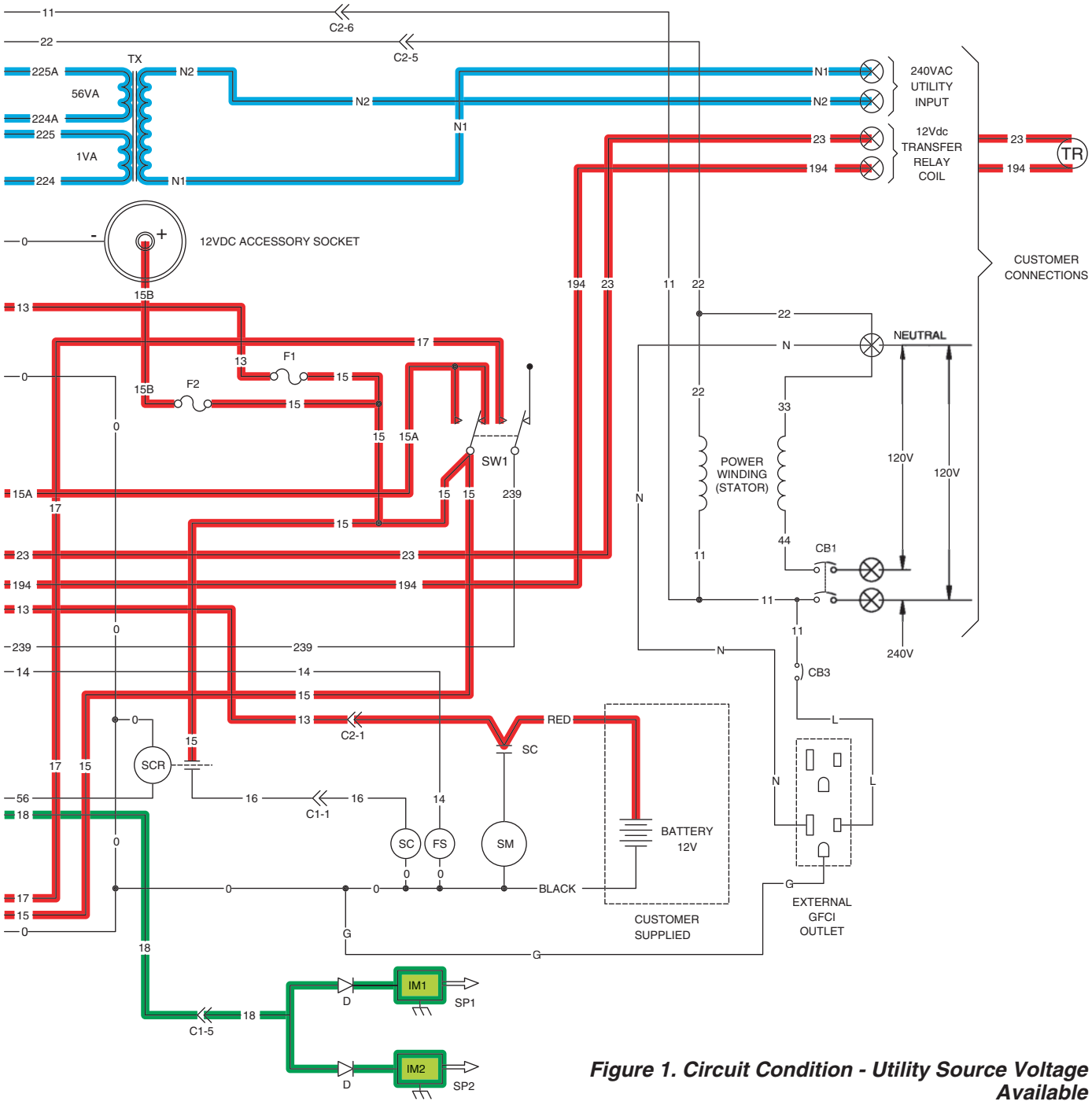
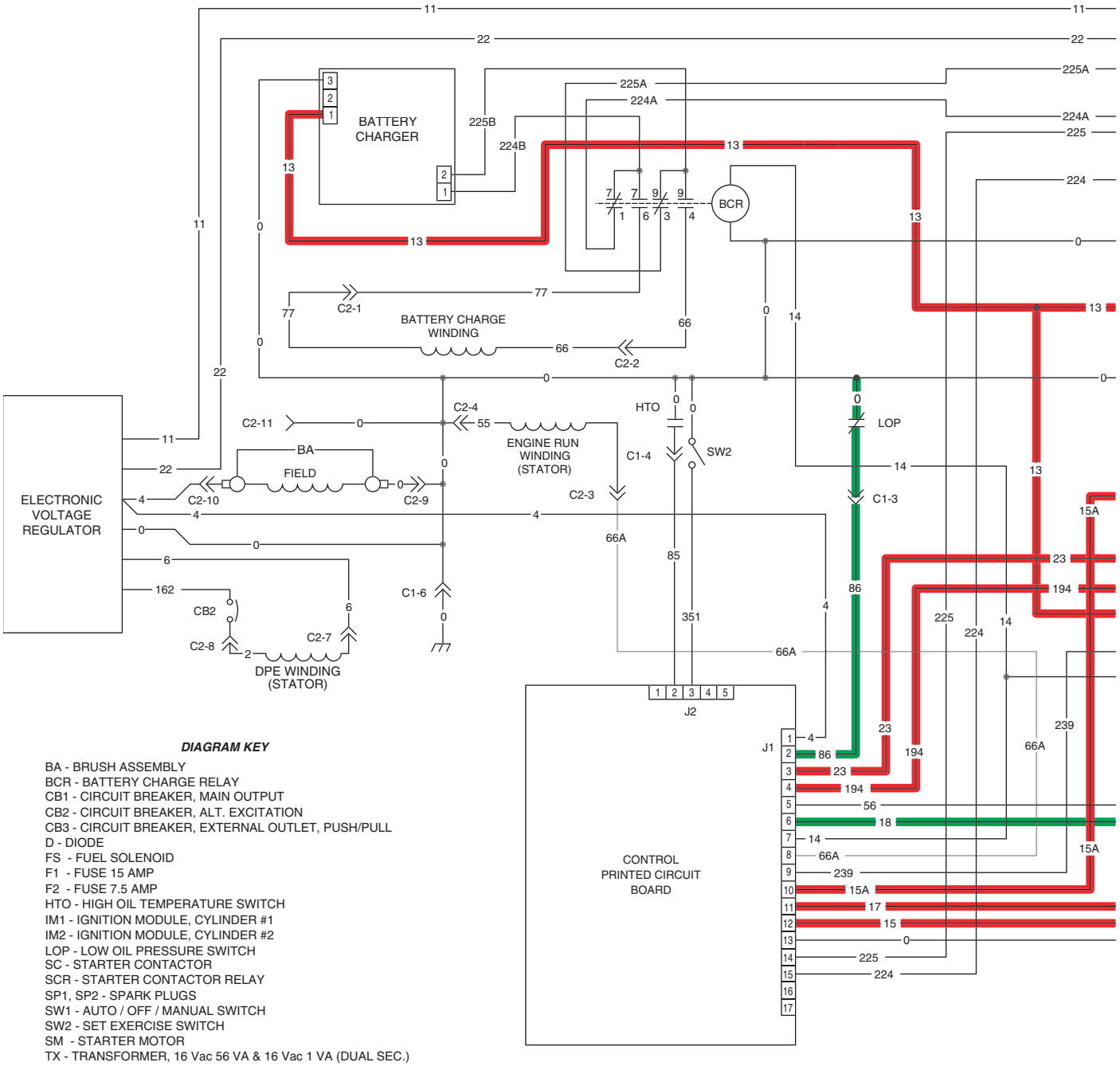


Figure 1. Circuit Condition - Utility Source Voltage Available

INITIAL DROPOUT OF UTILITY SOURCE VOLTAGE

Refer to Figure 2, above. Should a "Utility" power source failure occur, circuit condition may be briefly described as follows:

- The circuit board constantly senses for an acceptable "Utility" source voltage, via transfer switch fuses F1/F2, transfer switch "Utility 1/Utility 2" terminals, connected wiring, control panel "Utility 1/Utility 2" terminals, the sensing transformer (TX), and Wires 224/225.



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FS - FUEL SOLENOID
F1 - FUSE 15 AMP
F2 - FUSE 7.5 AMP
HTO - HIGH OIL TEMPERATURE SWITCH
IM1 - IGNITION MODULE, CYLINDER #1
IM2 - IGNITION MODULE, CYLINDER #2
LOP - LOW OIL PRESSURE SWITCH
SC - STARTER CONTACTOR
SCR - STARTER CONTACTOR RELAY
SP1, SP2 - SPARK PLUGS
SW1 - AUTO / OFF / MANUAL SWITCH
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SM - STARTER MOTOR
TX - TRANSFORMER, 16 Vac 56 VA & 16 Vac 1 VA (DUAL SEC.)

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= AC VOLTAGE
= GROUND FOR CONTROL PURPOSES
= 12 VDC DURING CRANKING ONLY
= 12 VDC DURING ENGINE RUN CONDITION

- Should "Utility" voltage drop below approximately 60 percent of the nominal source voltage, a 15-second timer on the circuit board will turn on.
- In Figure 2, the 15-second timer is still timing and engine cranking has not yet begun.
- The Auto-Off-Manual switch is shown in its AUTO position. Battery voltage is available to the circuit board, via Wire 13, 15 amp fuse (F1), Wire 15, the Auto-Off-Manual switch (SW1), Wire 15A, and Pin 10 of the circuit board connector.

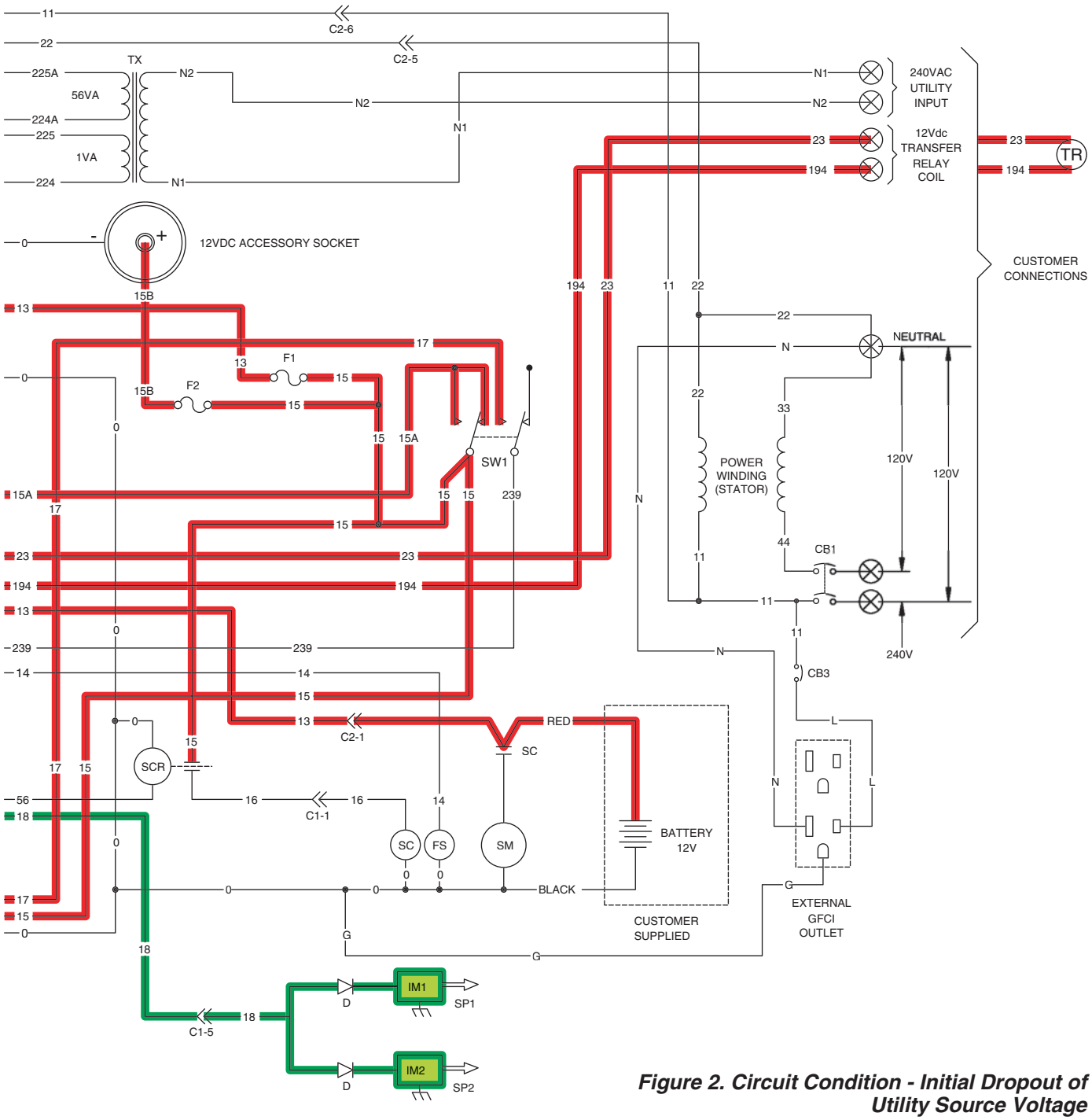
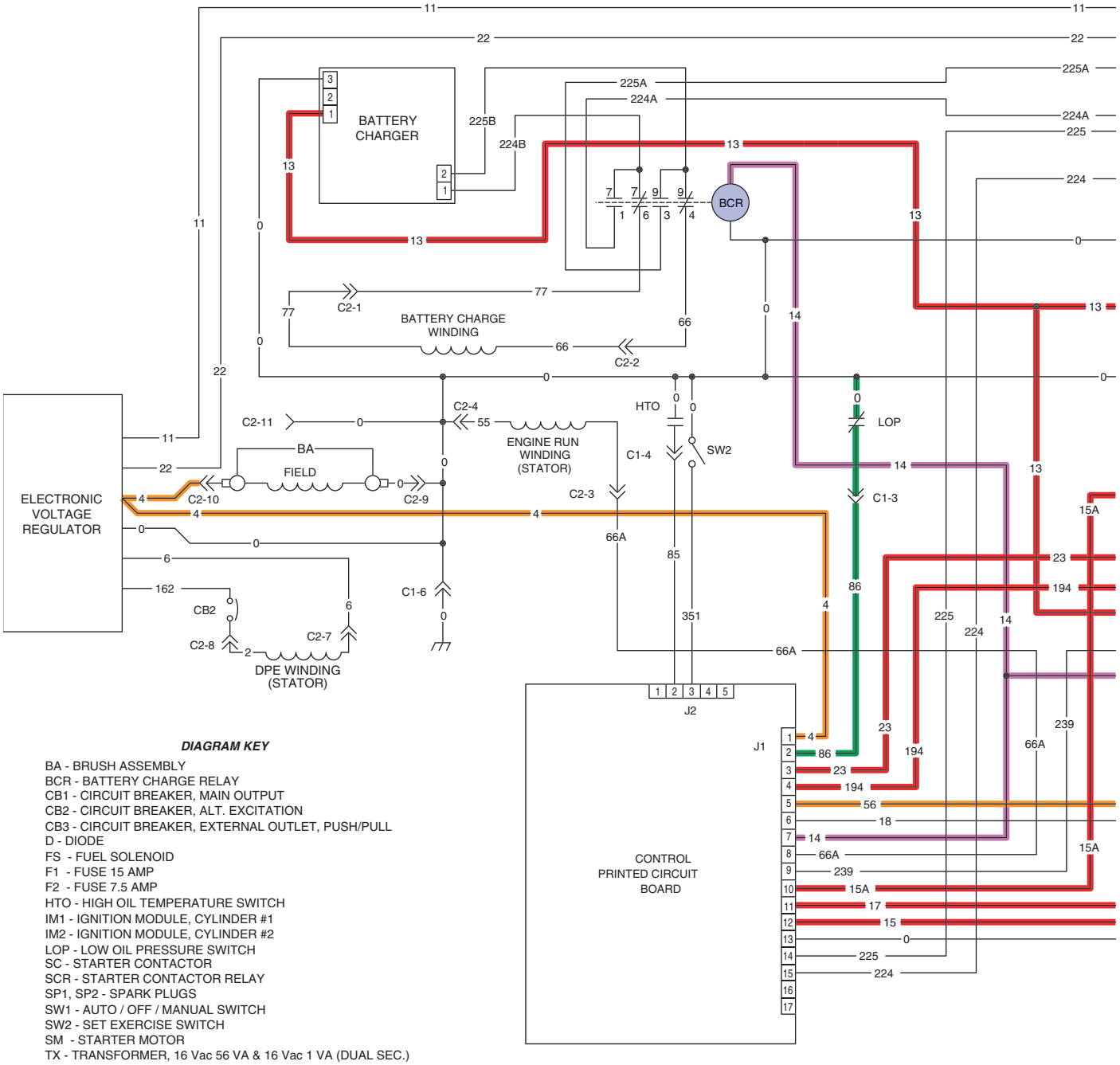


Figure 2. Circuit Condition - Initial Dropout of Utility Source Voltage

UTILITY VOLTAGE DROPOUT / ENGINE CRANKING

- After fifteen (15) seconds and when the circuit board's 15-second timer has timed out, if "Utility" voltage is still below 60 percent of nominal, circuit board action will energize the circuit board's crank and run relays (K1 and K2) simultaneously.
- The crank relay (K1) will remain energized for about 15 seconds on the first crank cycle. The relay will then de-energize for 7 seconds and will again energize. This time it will remain energized for 7 seconds. Thus, the engine will crank cyclically for 7 second crank-rest cycles. This cyclic cranking will continue until either the engine starts or until about ninety (90) seconds of crank-rest cycles have elapsed.
- When the crank relay (K1) is energized, circuit board action delivers 12 volts DC to a starter contactor relay (SCR), via Wire 56. When the SCR energizes, its contacts close and battery power is delivered to a starter contactor (SC). When the SC energizes, its contacts close and battery power is delivered to the starter motor (SM).The engine cranks.



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= 12 VDC DURING ENGINE RUN CONDITION

- When the circuit board's run relay (K2) energizes, 12 volts DC is delivered to a fuel solenoid (FS), via Wire 14. The fuel solenoid (FS) energizes open and fuel is available to the engine. Wire 14 energizes the battery charge relay (BCR), which will allow the BCR to power the battery charger.
- As the engine cranks, magnets on the engine flywheel induce a high voltage into the engine ignition modules (IM1/IM2). A spark is produced that jumps the spark plug (SP1/SP2) gap.
- During cranking, Wire 4 supplies 2-3 VDC (8-9 VDC isolated) to the rotor for field flash.
- With ignition and fuel flow available the engine can start.

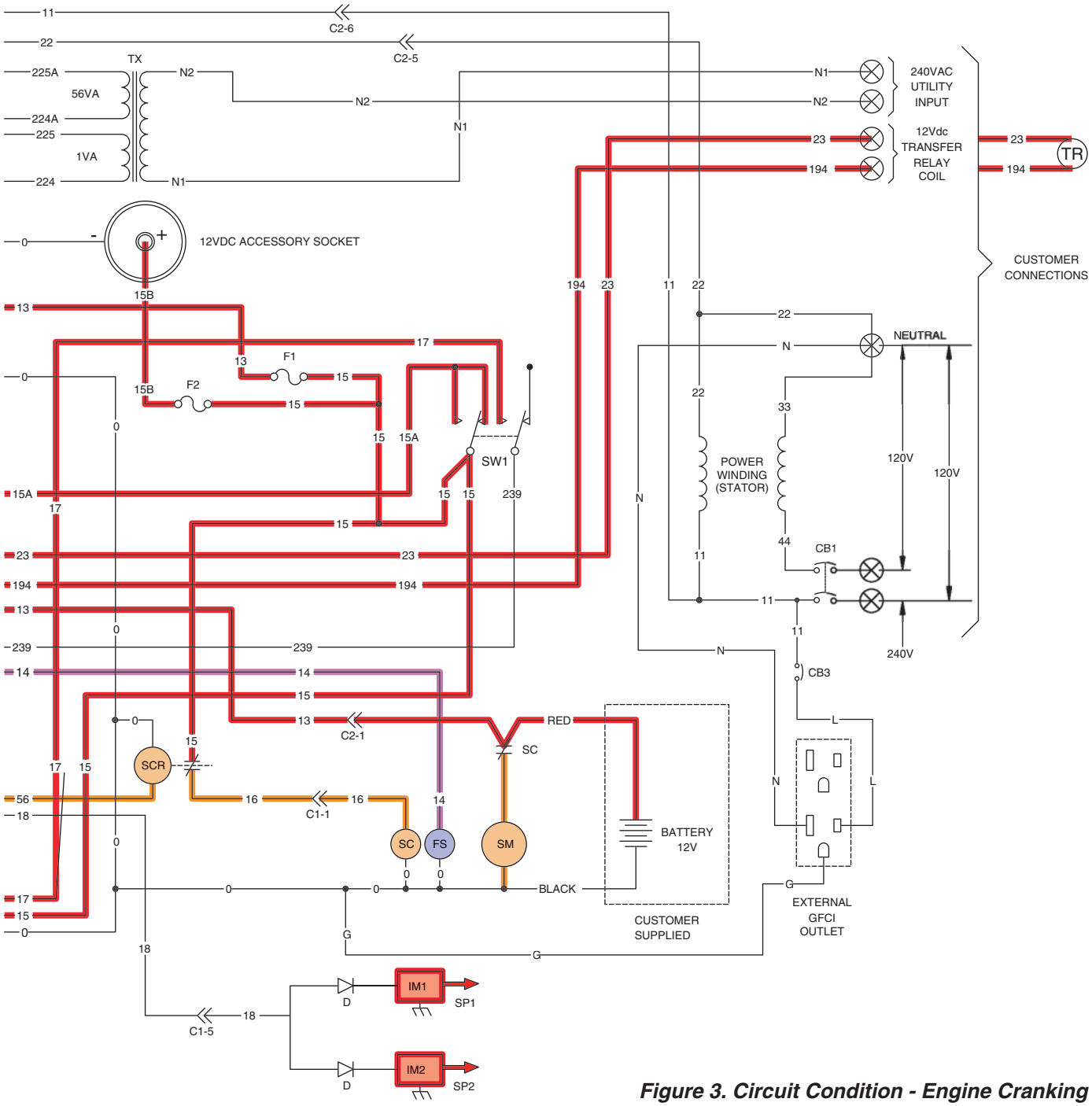
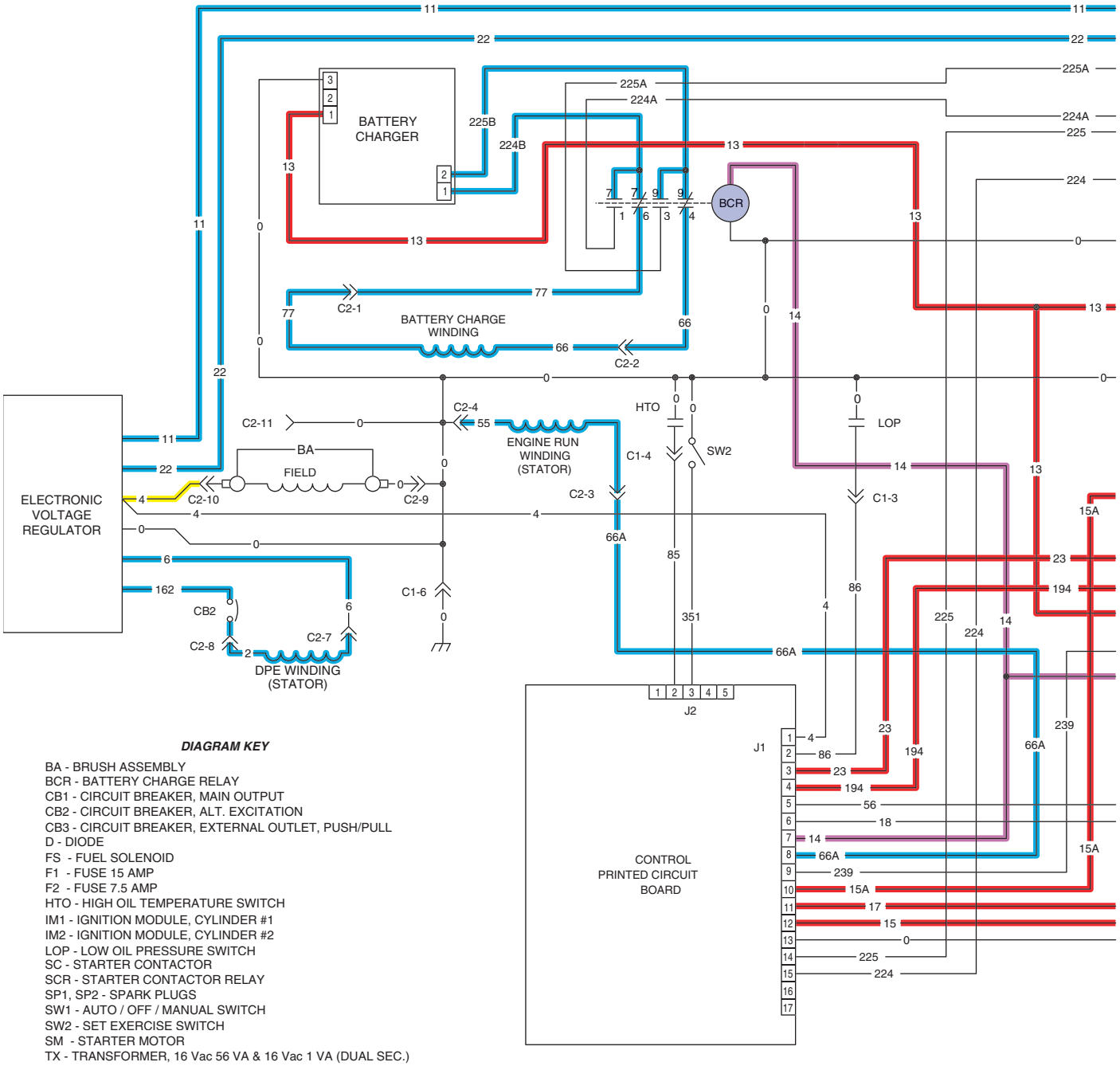


Figure 3. Circuit Condition - Engine Cranking

ENGINE STARTUP AND RUNNING

With the fuel solenoid open and ignition occurring, the engine starts. Engine startup and running may be briefly described as follows:

- An AC voltage/frequency signal is delivered to the circuit board from the generator engine run winding, via Wire 66A. When AC frequency reaches approximately 30 Hz, the circuit board (a) terminates cranking, and (b) turns on an "engine warm-up timer".



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= 12 VDC DURING CRANKING ONLY
= 12 VDC DURING ENGINE RUN CONDITION

- The "engine warm-up timer" will run for about 15 seconds. When this timer finishes timing, board action will initiate transfer to the "Standby" power source. As shown in Figure 4 (above), the timer is still running and transfer has not yet occurred.
- Generator AC output is available to transfer switch terminal lugs E1/E2 and to the normally open contacts of a transfer relay. However, the transfer relay is de-energized and its contacts are open.

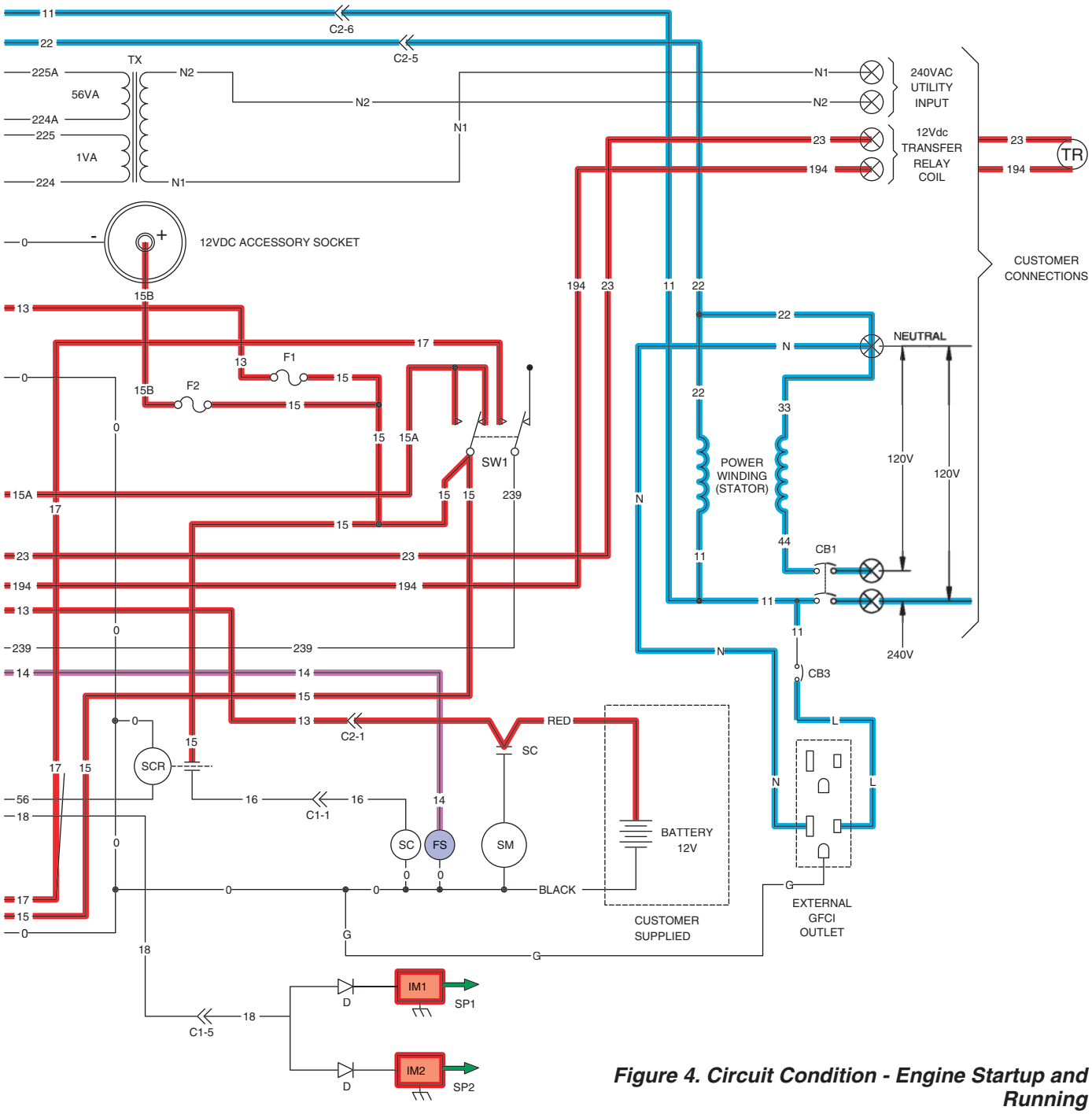
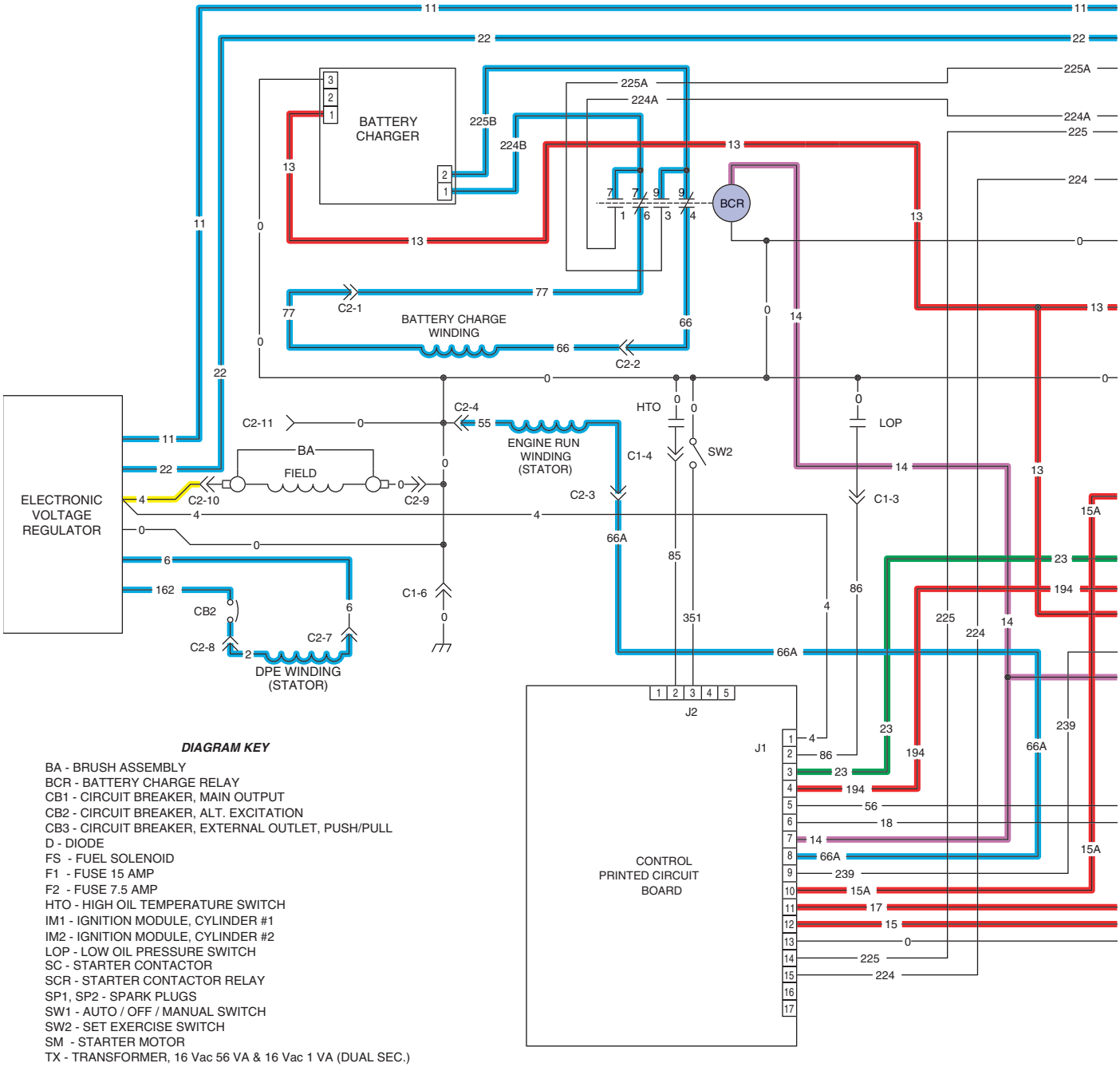


Figure 4. Circuit Condition - Engine Startup and Running

INITIAL TRANSFER TO THE "STANDBY" SOURCE

The generator is running, the circuit board's "engine warm-up timer" is timing, and generator AC output is available to transfer switch terminal lugs E1 and E2 and to the open contacts on the transfer relay. Initial transfer to the "Standby" power supply may be briefly described as follows:

- The circuit board delivers a 12 volts DC output to the transfer relay (TR) actuating coil, via Wire 194, and terminal A of the transfer relay (TR) in the transfer switch. This 12 volts DC circuit is completed back to the board, via transfer relay terminal B, and Wire 23. However, circuit board action holds the Wire 23 circuit open to ground and the transfer relay (TR) is de-energized.
- When the circuit board's "engine warm-up timer" times out, circuit board action completes the Wire 23 circuit to ground. The transfer relay then energizes and its normally open contacts close.
- "Standby" power is now delivered to the standby closing coil (C2), via Wires E1 /E2, the normally open transfer relay contacts, Wire 205, limit switch



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= 12 VDC DURING ENGINE RUN CONDITION

XB1, Wire B, and a bridge rectifier. The standby closing coil energizes and the main current carrying contacts of the transfer switch are actuated to their 'Standby" source side.

- As the main contacts move to their "Standby" source side, a mechanical interlock actuates limit switch XB1 to its open position and limit switch XA1 to its "Utility" side position. When XB1 opens, standby closing coil C2 3 de-energizes.
- "Standby" power is delivered to the "Load" terminals (T1/T2) of the transfer switch.

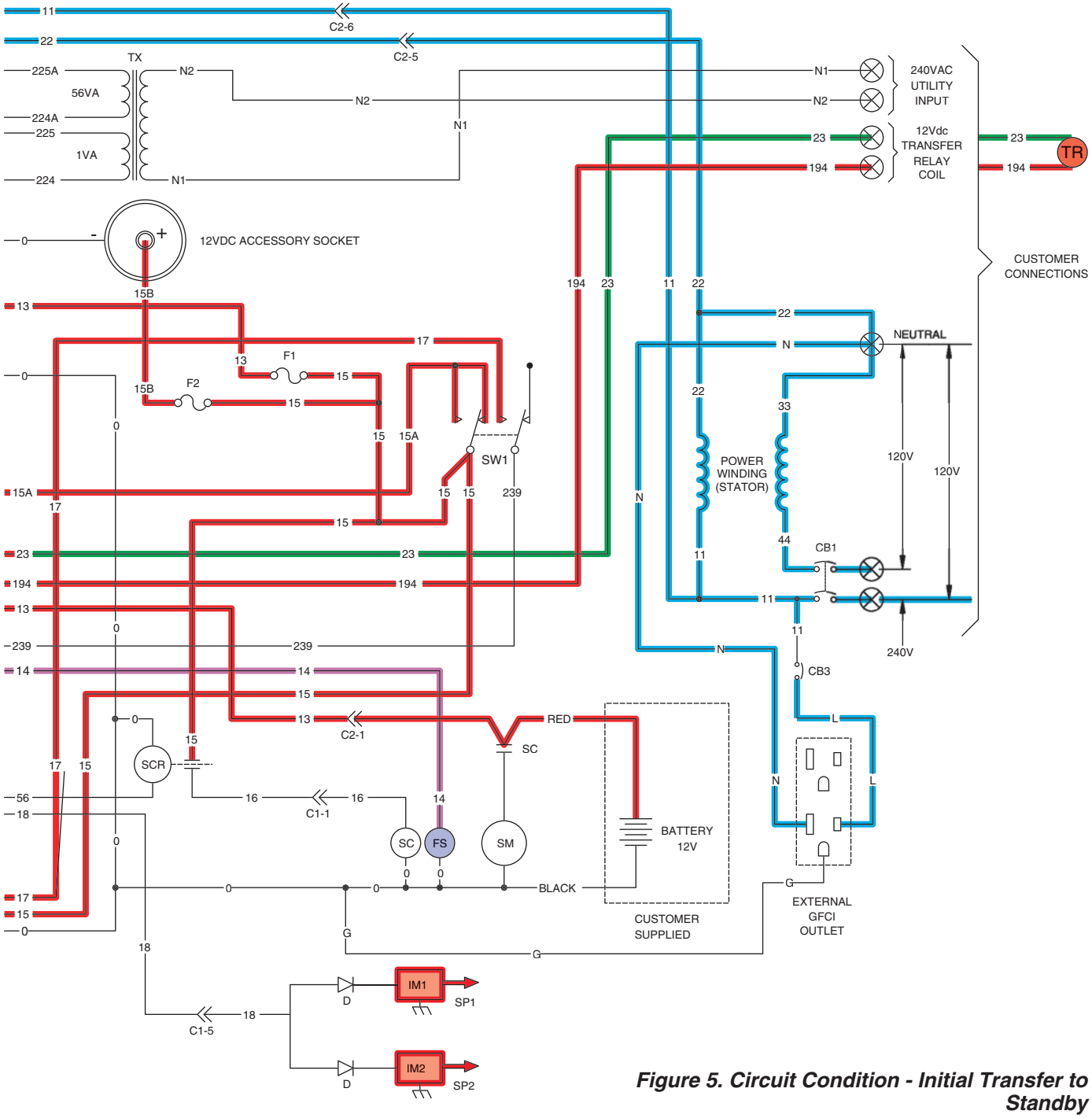
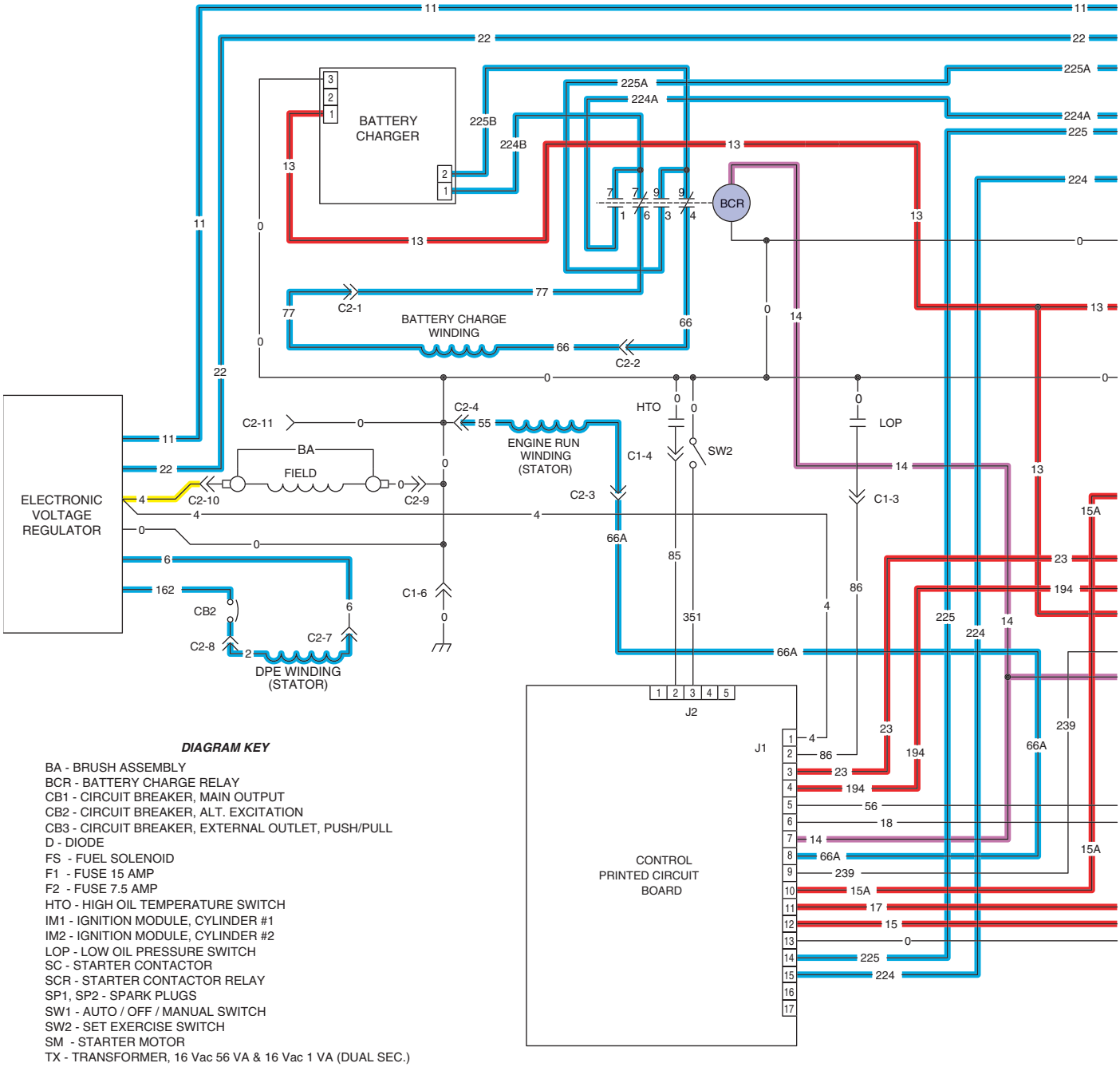


Figure 5. Circuit Condition - Initial Transfer to Standby

UTILITY VOLTAGE RESTORED / RE-TRANSFER TO UTILITY

The "Load" is powered by the "Standby" power supply. The circuit board continues to seek an acceptable "Utility" source voltage. On restoration of "Utility" source voltage, the following events will occur:

- On restoration of utility source voltage above 80 percent of the nominal rated voltage, a "retransfer time delay" on the circuit board starts timing. The timer will run for about fifteen (15) seconds.
- At the end of fifteen (15) seconds, the "retransfer time delay" will stop timing and circuit board action will open the Wire 23 circuit to ground. The transfer relay (TR) will then de-energize.
- When the transfer relay (TR) de-energizes, its normally-closed contacts close. "Utility" source voltage is then delivered to the utility closing coil (C1), via Wires N1A/N2A, the closed TR contacts, Wire 126, limit switch XA1, and a bridge rectifier.
- The utility closing coil (C1) energizes and moves the main current carrying contacts to their "Neutral" position. The main contacts move to an over center



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= 12 VDC DURING CRANKING ONLY
= 12 VDC DURING ENGINE RUN CONDITION

position past "Neutral" and spring force closes them to their "Utility" side. "Load" terminals are now powered by the "Utility" source.

- Movement of the main contacts to 'Utility" actuates limit switches XA1/XB1. XA1 opens and XB1 actuates to its "Standby" source side.
- The generator continues to run.

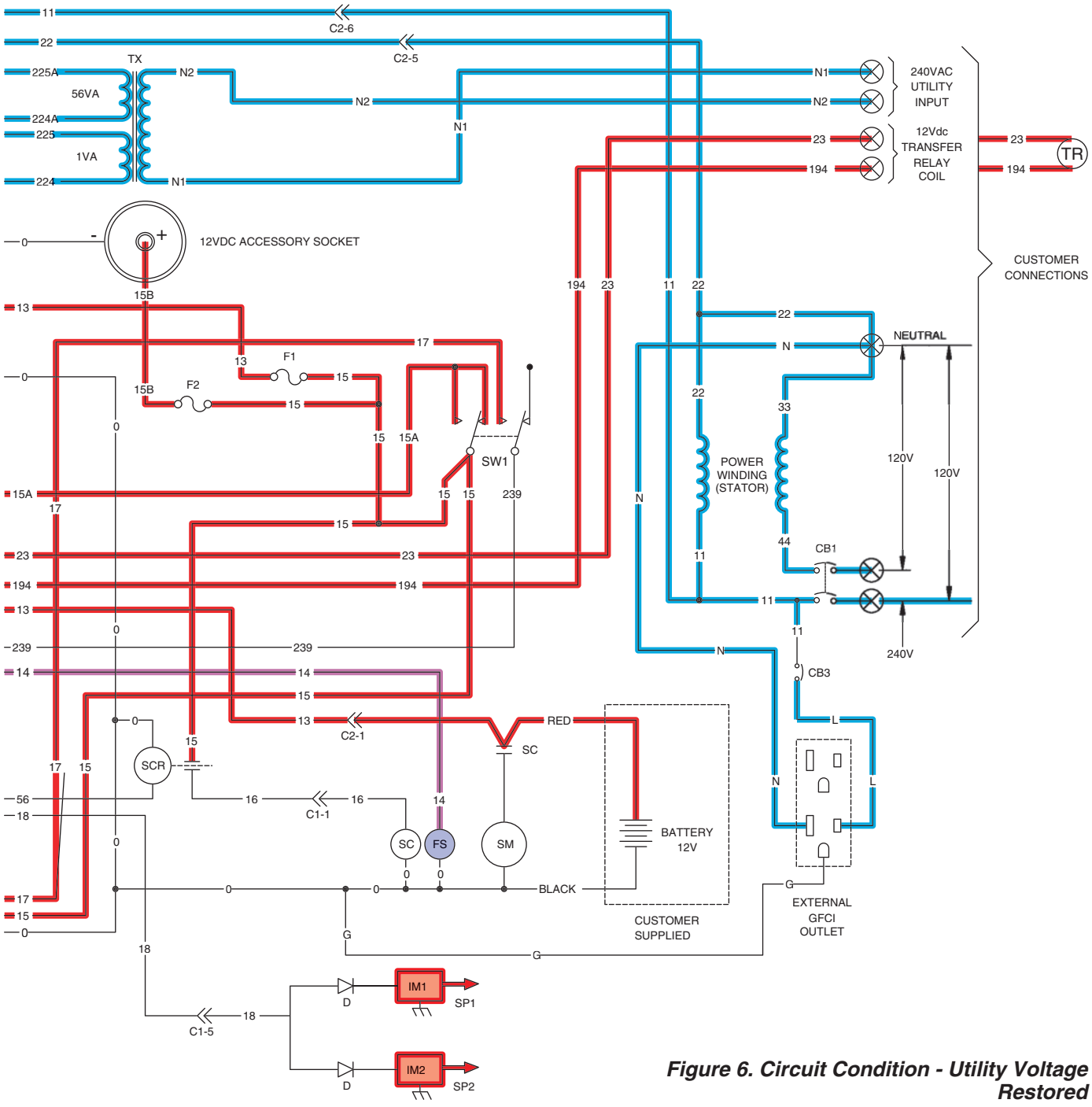
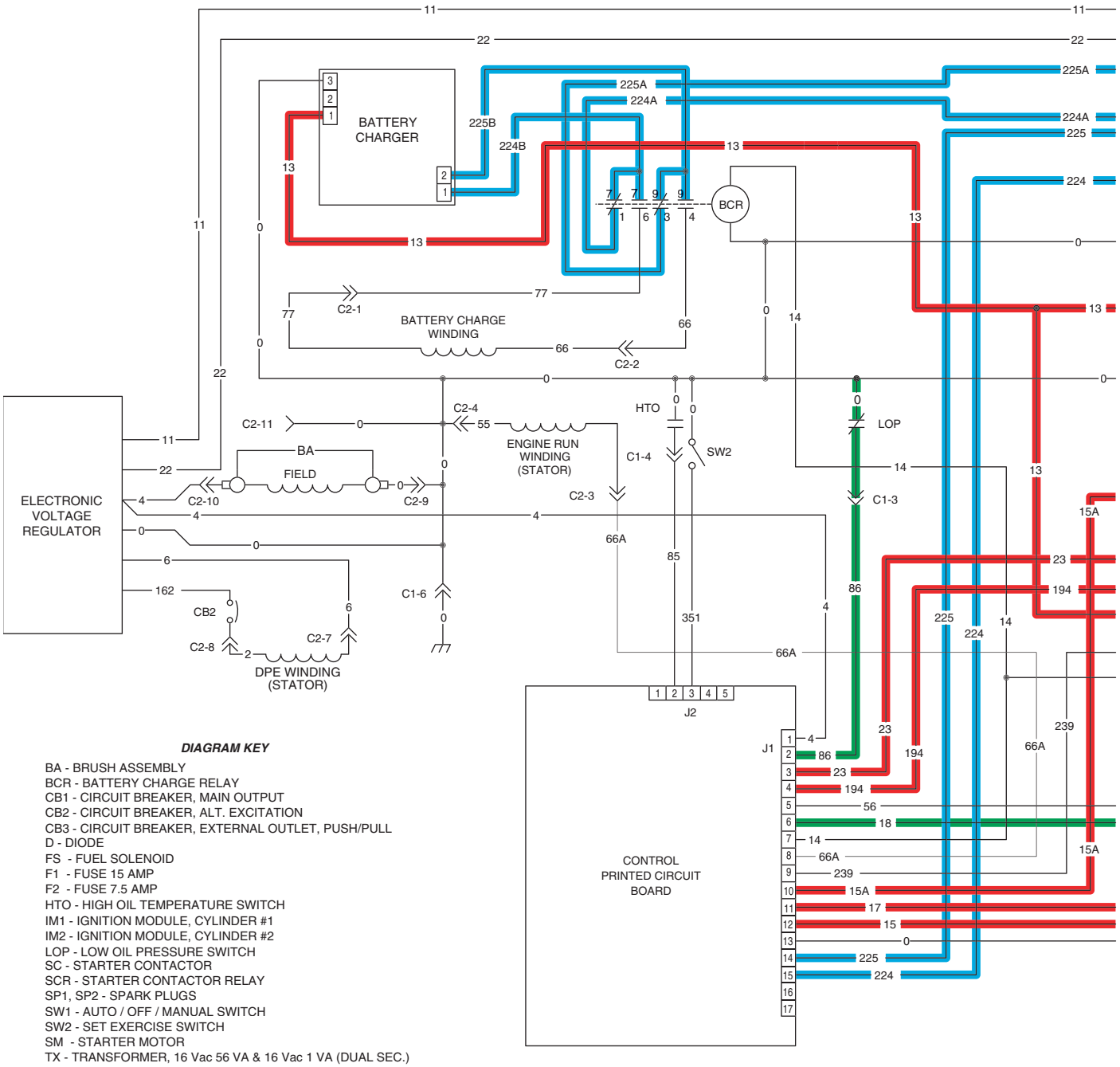


Figure 6. Circuit Condition - Utility Voltage Restored

ENGINE SHUTDOWN

Following retransfer back to the "Utility" source, an "engine cool-down timer" on the circuit board starts timing. When that timer has timed out (approximately one minute), circuit board action will de-energize the circuit board's run relay (K2). The following events will then occur:

- The DC circuit to Wire 14 and the fuel solenoid (FS) will be opened. The fuel solenoid (FS) will de-energize and close to terminate the engine fuel supply.
- The hourmeter (if equipped) connected to Wire 14 will be opened and clock function of the hourmeter will stop.



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= 12 VDC DURING ENGINE RUN CONDITION

- The battery charge relay (BCR) connected to Wire 14 will be de-energized. This will cause transformer (TX) voltage to power the battery charger again.
- Circuit board action will connect the engine's ignition shutdown module (ISM) to ground, via Wire 18, circuit board Pin 13, and Wire 0. Ignition will be terminated.
- Without fuel flow and without ignition, the engine will shut down.

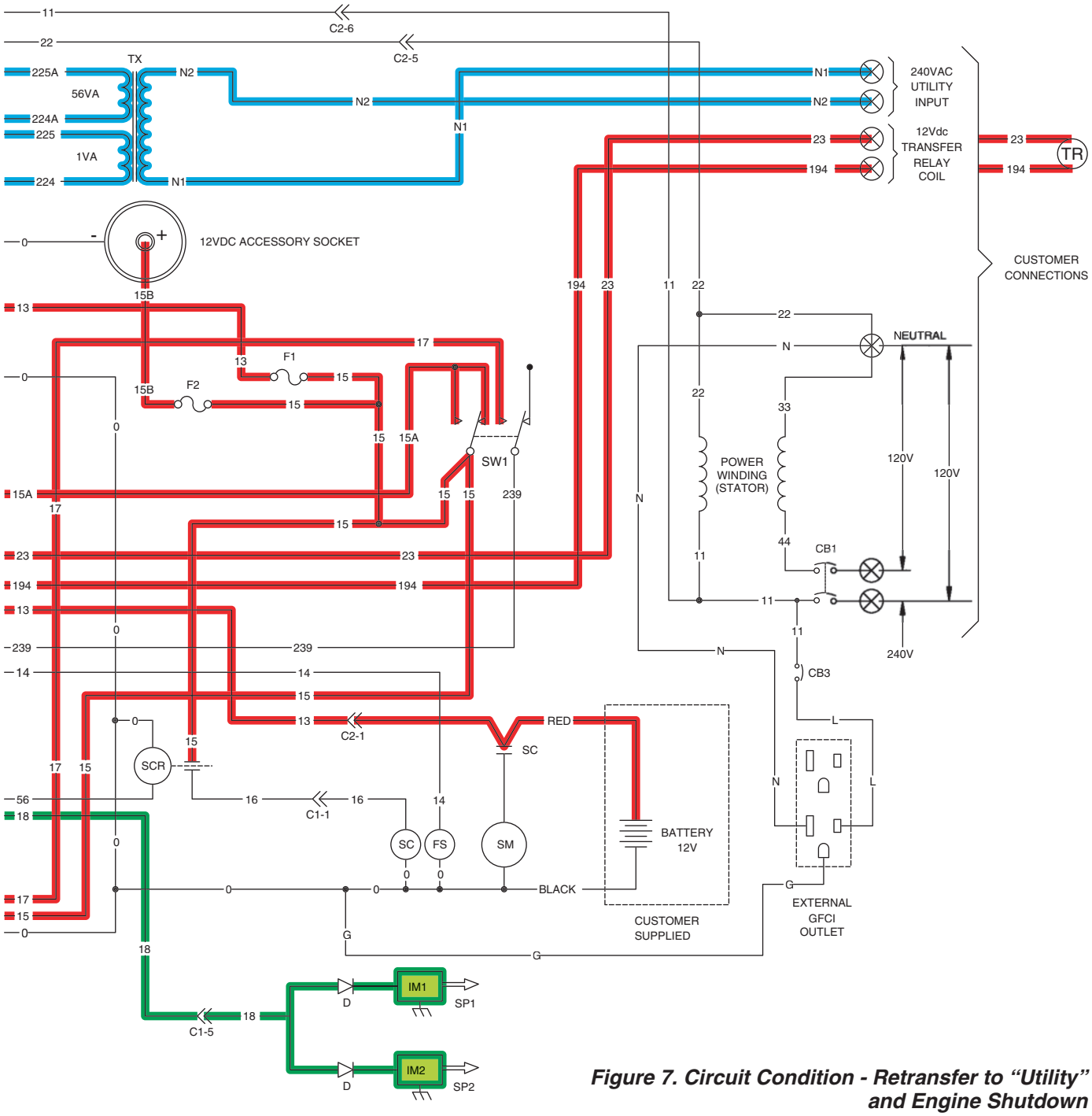
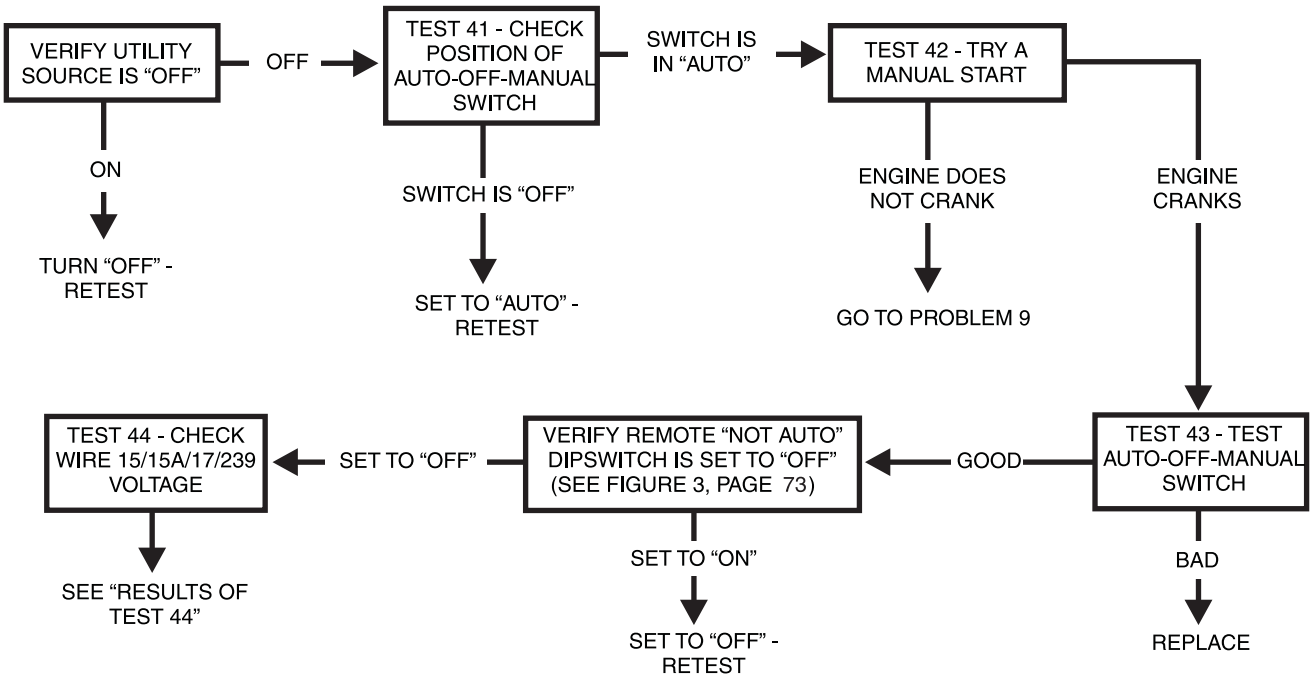
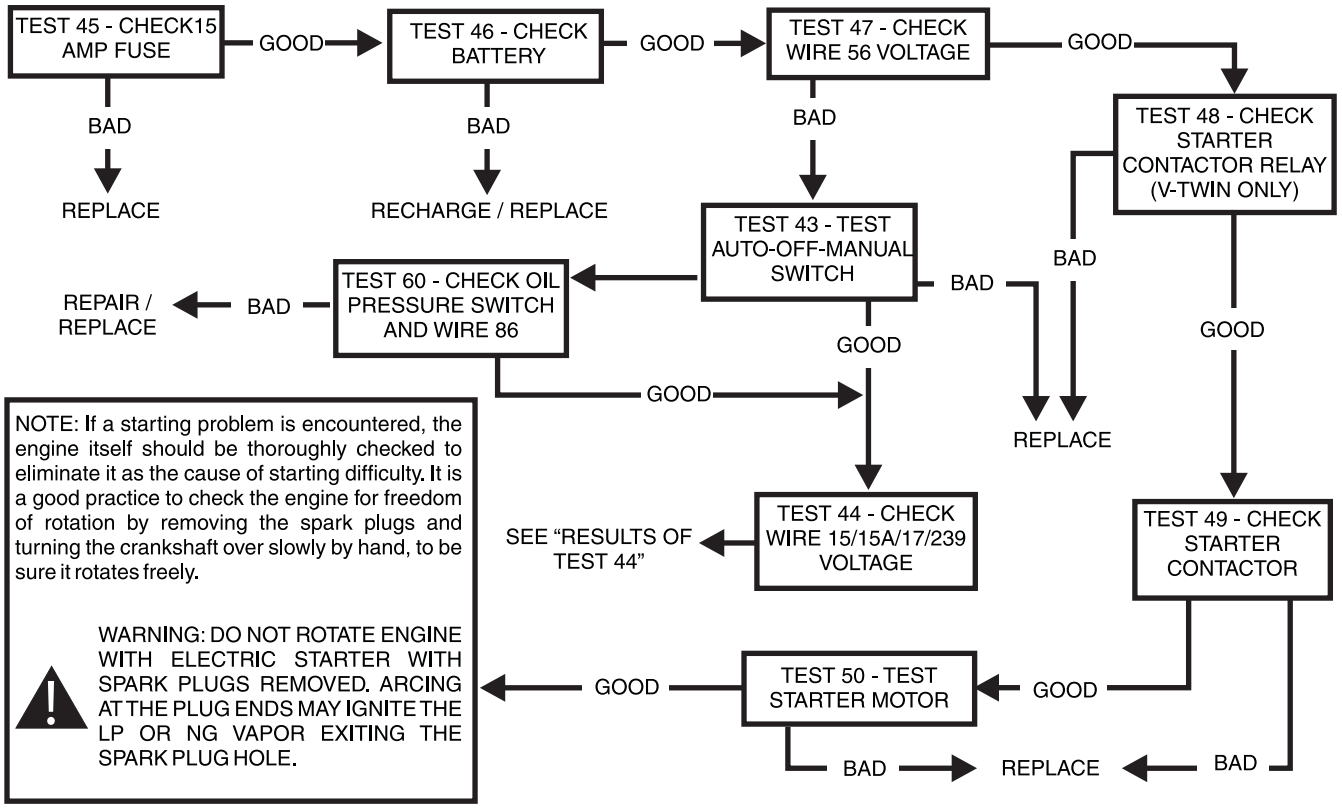


Figure 7. Circuit Condition - Retransfer to "Utility" and Engine Shutdown

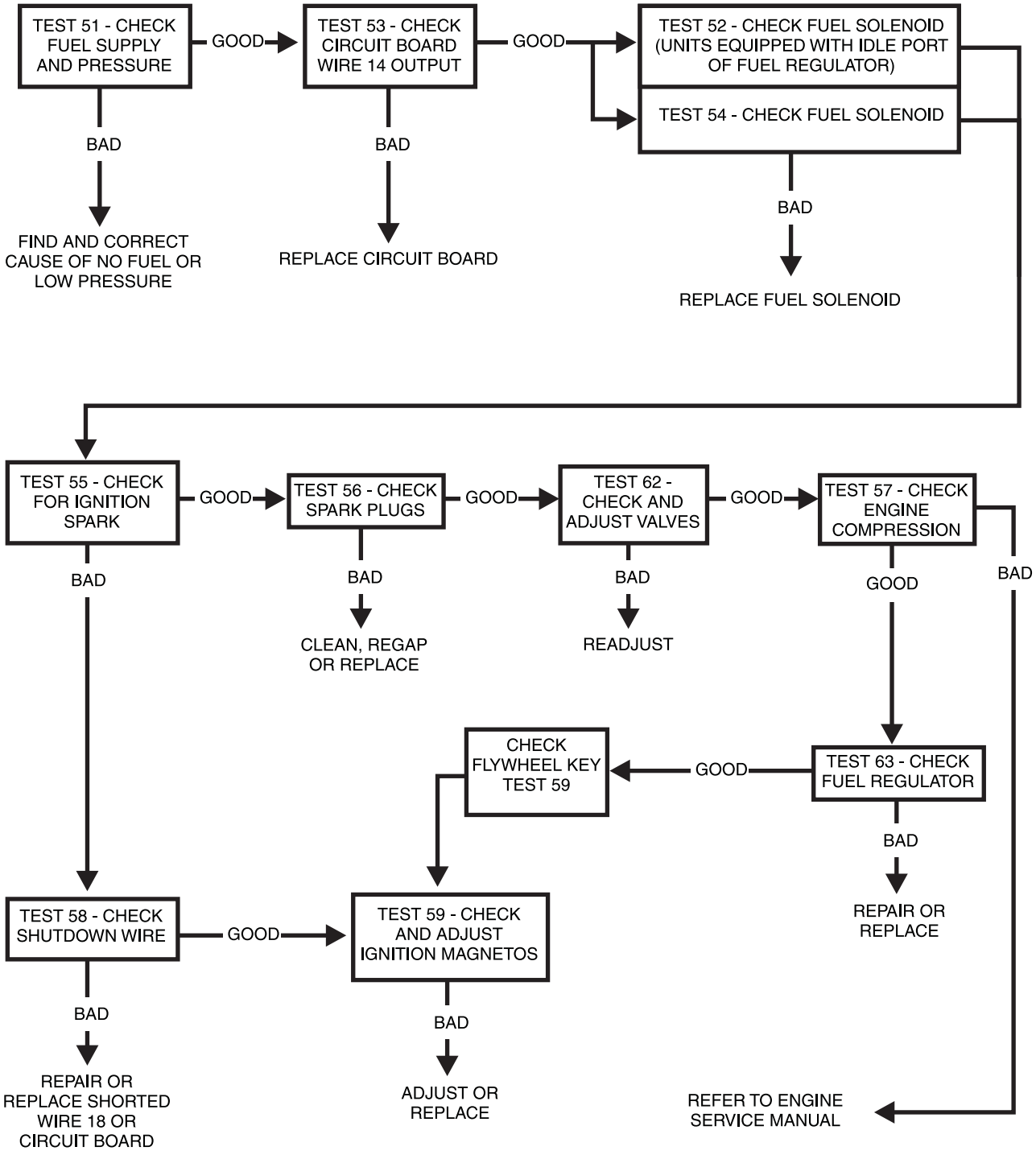
Problem 8 - Engine Will Not Crank When Utility Power Source Fails


VERIFY UTILITY SOURCE IS "OFF"
OFF
TEST 41 - CHECK POSITION OF AUTO-OFF-MANUAL SWITCH
SWITCH IS IN "AUTO"
TEST 42 - TRY A MANUAL START
ON
TURN "OFF" - RETEST
SWITCH IS "OFF"
SET TO "AUTO" - RETEST
ENGINE DOES NOT CRANK
GO TO PROBLEM 9
ENGINE CRANKS
TEST 44 - CHECK WIRE 15/15A/17/239 VOLTAGE
SET TO "OFF"
VERIFY REMOTE "NOT AUTO" DIPSWITCH IS SET TO "OFF" (SEE FIGURE 3, PAGE 73)
GOOD
TEST 43 - TEST AUTO-OFF-MANUAL SWITCH
SEE "RESULTS OF TEST 44"
SET TO "ON"
SET TO "OFF" - RETEST
BAD
REPLACE

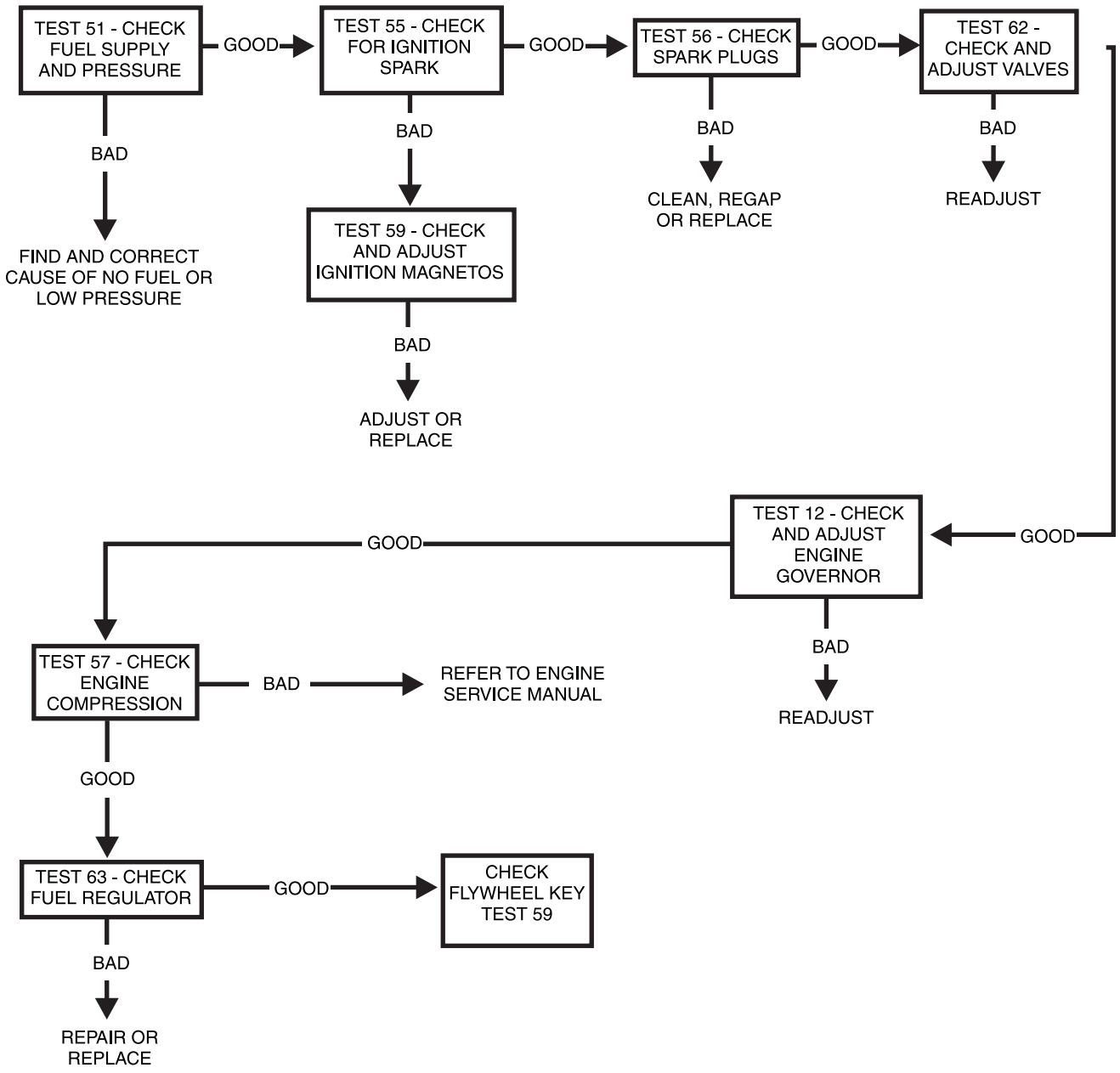
Problem 9 - Engine Will Not Crank When AUTO-OFF-MANUAL Switch is Set to "MANUAL"


TEST 45 - CHECK15 AMP FUSE
GOOD
TEST 46 - CHECK BATTERY
GOOD
TEST 47 - CHECK WIRE 56 VOLTAGE
GOOD
BAD
REPLACE
BAD
RECHARGE / REPLACE
BAD
TEST 48 - CHECK STARTER CONTACTOR RELAY (V-TWIN ONLY)
TEST 43 - TEST AUTO-OFF-MANUAL SWITCH
BAD
REPAIR / REPLACE
BAD
TEST 60 - CHECK OIL PRESSURE SWITCH AND WIRE 86
BAD
GOOD
GOOD
GOOD
REPLACE
NOTE: If a starting problem is encountered, the engine itself should be thoroughly checked to eliminate it as the cause of starting difficulty. It is a good practice to check the engine for freedom of rotation by removing the spark plugs and turning the crankshaft over slowly by hand, to be sure it rotates freely.
WARNING: DO NOT ROTATE ENGINE WITH ELECTRIC STARTER WITH SPARK PLUGS REMOVED. ARCING AT THE PLUG ENDS MAY IGNITE THE LP OR NG VAPOR EXITING THE SPARK PLUG HOLE.
SEE "RESULTS OF TEST 44"
TEST 44 - CHECK WIRE 15/15A/17/239 VOLTAGE
TEST 49 - CHECK STARTER CONTACTOR
GOOD
TEST 50 - TEST STARTER MOTOR
GOOD
BAD
REPLACE
BAD

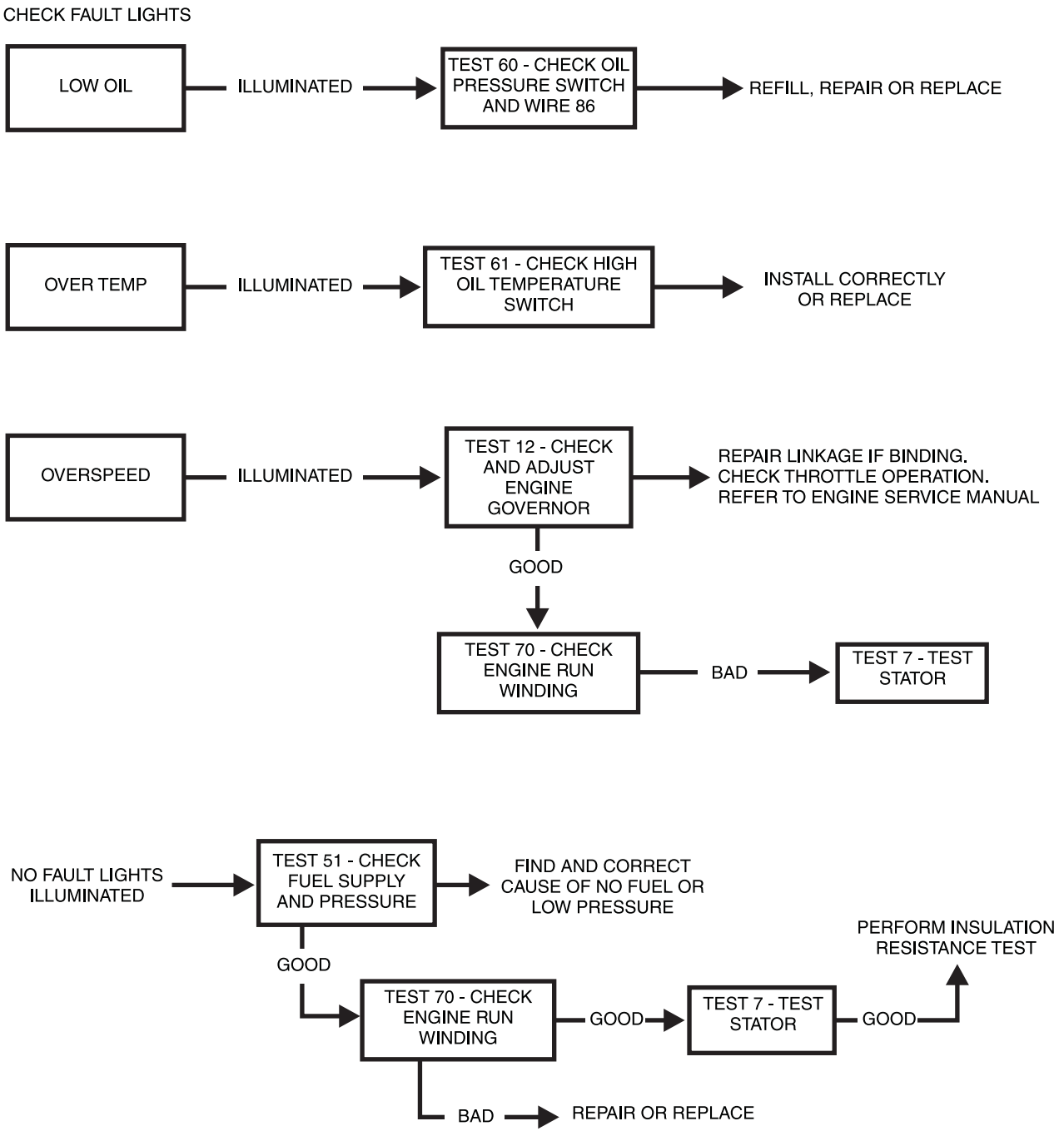
Problem 10 - Engine Cranks but Won't Start



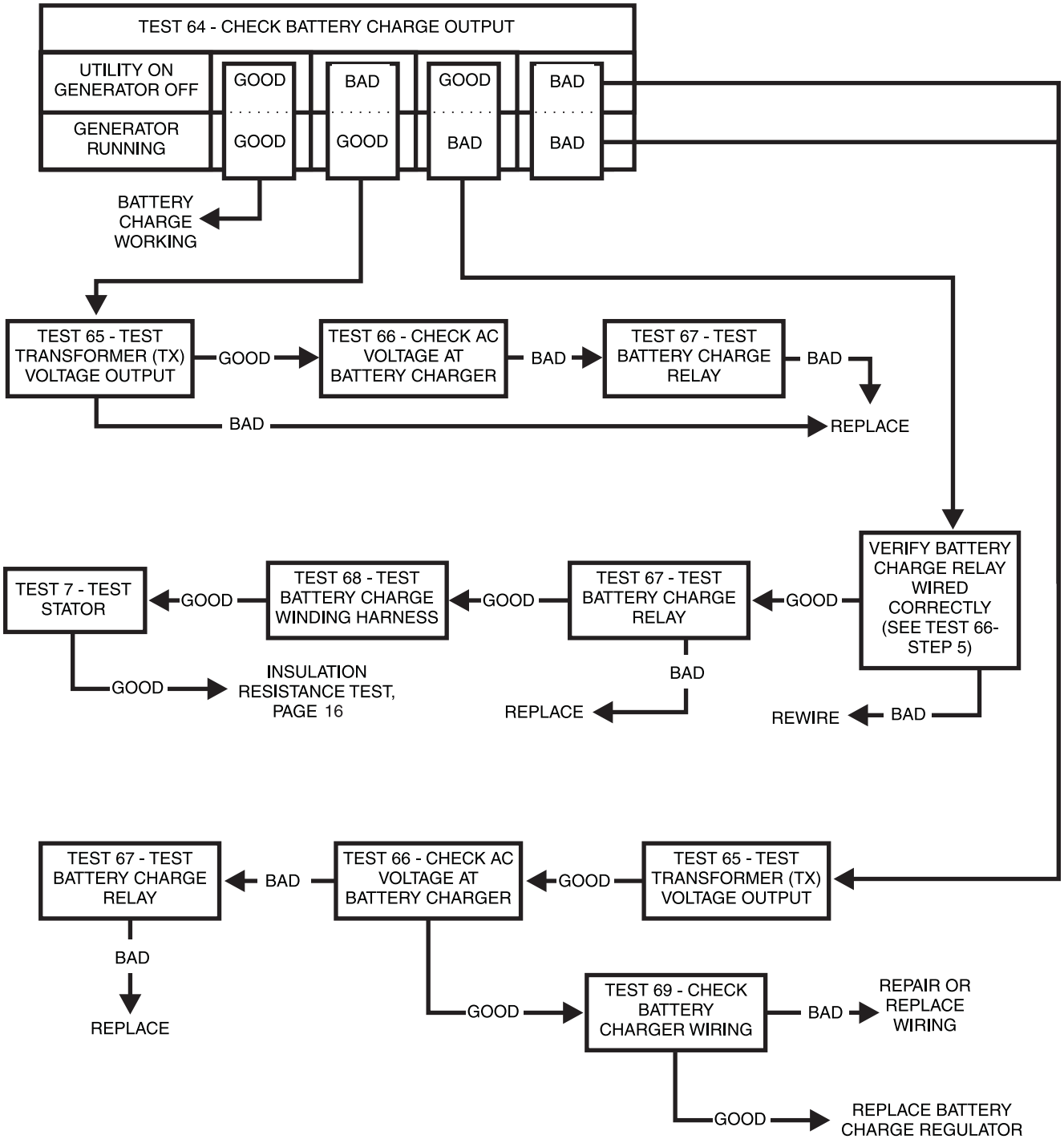
Problem 11 - Engine Starts Hard and Runs Rough / Lacks Power



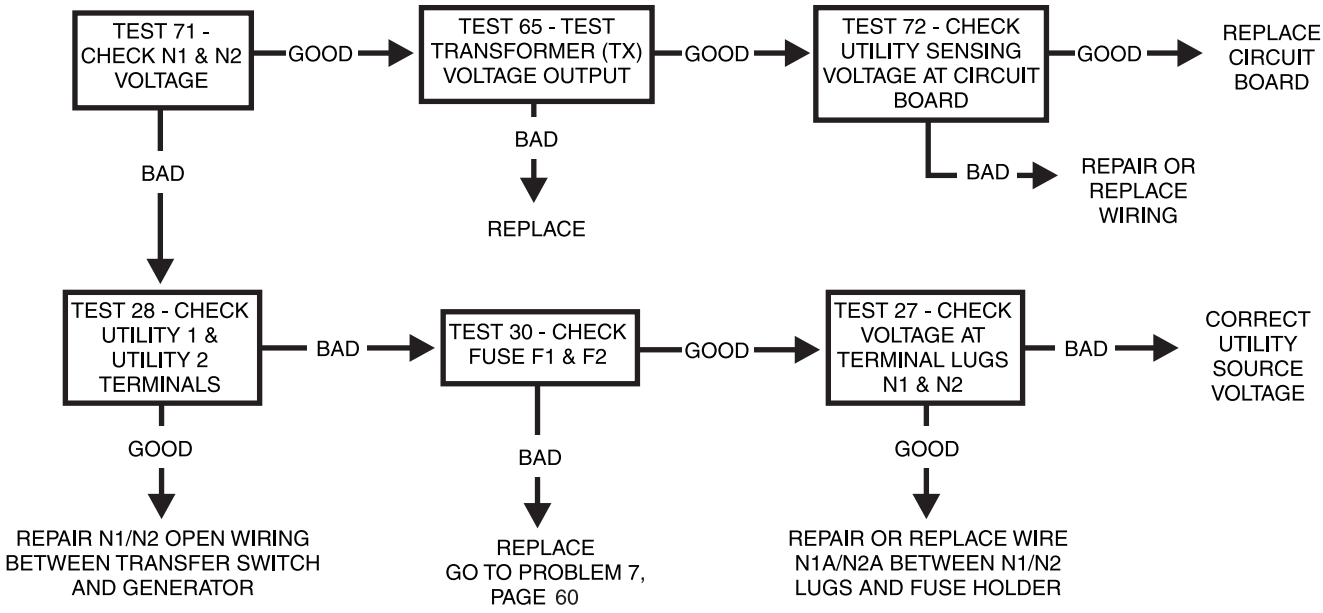
Problem 12 - Engine Starts and Runs, Then Shuts Down


CHECK FAULT LIGHTS
LOW OIL
ILLUMINATED
TEST 60 - CHECK OIL PRESSURE SWITCH AND WIRE 86
REFILL, REPAIR OR REPLACE
OVER TEMP
ILLUMINATED
TEST 61 - CHECK HIGH OIL TEMPERATURE SWITCH
INSTALL CORRECTLY OR REPLACE
OVERSPEED
ILLUMINATED
TEST 12 - CHECK AND ADJUST ENGINE GOVERNOR
REPAIR LINKAGE IF BINDING. CHECK THROTTLE OPERATION. REFER TO ENGINE SERVICE MANUAL
GOOD
TEST 70 - CHECK ENGINE RUN WINDING
BAD
TEST 7 - TEST STATOR
NO FAULT LIGHTS ILLUMINATED
TEST 51 - CHECK FUEL SUPPLY AND PRESSURE
FIND AND CORRECT CAUSE OF NO FUEL OR LOW PRESSURE
GOOD
TEST 70 - CHECK ENGINE RUN WINDING
GOOD
TEST 7 - TEST STATOR
GOOD
PERFORM INSULATION RESISTANCE TEST
BAD
REPAIR OR REPLACE

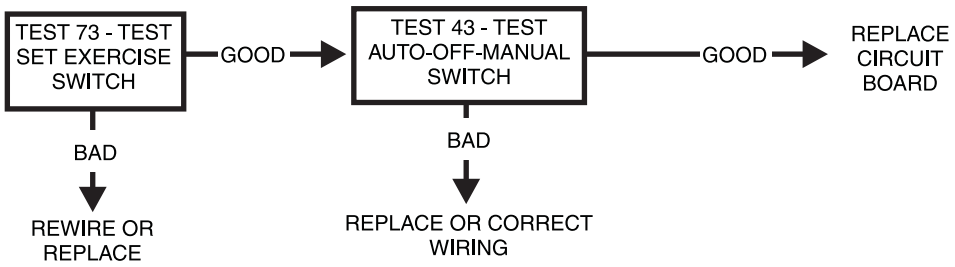
Problem 13 - No Battery Charge



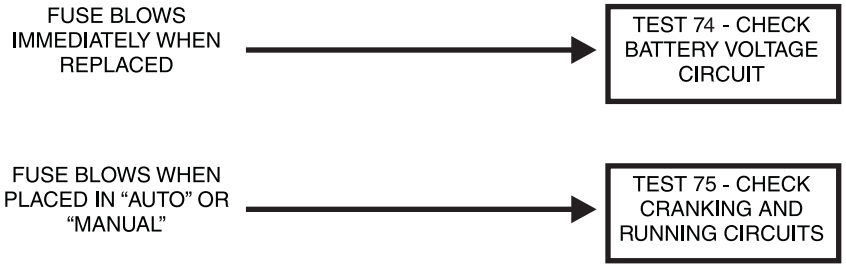
Problem 14 - Unit Starts and Transfer Occurs When Utility Power Is Available


TEST 71 - CHECK N1 & N2 VOLTAGE
GOOD
TEST 65 - TEST TRANSFORMER (TX) VOLTAGE OUTPUT
GOOD
TEST 72 - CHECK UTILITY SENSING VOLTAGE AT CIRCUIT BOARD
GOOD
REPLACE CIRCUIT BOARD
BAD
REPLACE
BAD
REPAIR OR REPLACE WIRING
BAD
TEST 28 - CHECK UTILITY 1 & UTILITY 2 TERMINALS
BAD
TEST 30 - CHECK FUSE F1 & F2
GOOD
TEST 27 - CHECK VOLTAGE AT TERMINAL LUGS N1 & N2
BAD
CORRECT UTILITY SOURCE VOLTAGE
GOOD
REPAIR N1/N2 OPEN WIRING BETWEEN TRANSFER SWITCH AND GENERATOR
BAD
REPLACE
GO TO PROBLEM 7, PAGE 60
GOOD
REPAIR OR REPLACE WIRE N1A/N2A BETWEEN N1/N2 LUGS AND FUSE HOLDER

Problem 15 - Generator Starts Immediately in Auto - No Transfer to Standby. Utility Voltage is Present



Problem 16 - 15 Amp Fuse (F1) Blown


FUSE BLOWS IMMEDIATELY WHEN REPLACED
TEST 74 - CHECK BATTERY VOLTAGE CIRCUIT
FUSE BLOWS WHEN PLACED IN "AUTO" OR "MANUAL"
TEST 75 - CHECK CRANKING AND RUNNING CIRCUITS

Problem 17 - 7.5 Amp Fuse (F2) Blown

THE 12 VDC ACCESSORY OUTLET IS CAPABLE OF DELIVERING A MAXIMUM OF 7.5 AMPS. IF THE ACCESSORY TO BE USED THROUGH THIS CIRCUIT DEMANDS TOO MUCH POWER, THE FUSE THAT PROTECTS THIS CIRCUIT WILL OPEN.

CHECK FOR OVERLOAD CONDITION.

INSTALL NEW FUSE AND RETEST.

IF FUSE STILL MELTS OPEN CHECK WIRE 15 BETWEEN 7.5A(F2) FUSE HOLDER AND THE 12 VDC ACCESSORY SOCKET FOR A SHORT TO GROUND.

Problem 18 - Generator Will Not Exercise

TEST 76 - TEST EXERCISE FUNCTION

INTRODUCTION

Perform these "Diagnostic Tests" in conjunction with the "Troubleshooting Flow Charts" of Section 4.3.

The test procedures and methods presented in this section are not exhaustive. We could not possibly know of, evaluate and advise the service trade of all conceivable ways in which testing and trouble diagnosis might be performed. We have not undertaken any such broad evaluation.

TEST 41 - CHECK POSITION OF AUTO-OFF-MANUAL SWITCH

DISCUSSION:

If the standby system is to operate automatically, the generator Auto-Off-Manual switch must be set to AUTO. That is, the generator will not crank and start on occurrence of a "Utility" power outage unless that switch is at AUTO. In addition, the generator will not exercise every seven (7) days as programmed unless the switch is at AUTO.

PROCEDURE:

With the Auto-Off-Manual switch set to "Auto," test automatic operation. Testing of automatic operation can be accomplished by turning OFF the Utility power supply to the transfer switch. When the utility power is turned OFF, the standby generator should crank and start. Following startup, transfer to the standby source should occur. Refer to Section 1.8 in this manual. An "Automatic Operating Sequences Chart" is provided in Section 1.7. Use the chart as a guide in evaluating automatic operation.

Following generator startup and transfer to the standby source, turn ON the utility power supply to the transfer switch. Retransfer back to the "Utility" source should occur. After an "engine cool down timer" has timed out, generator shutdown should occur.

RESULTS:

1. If normal automatic operation is obtained, discontinue tests.
2. If engine does not crank when "Utility" power is turned off, proceed to Test 42.
3. If engine cranks but won't start, go to Problem 10 in Section 4.3.
4. If engine cranks and starts, but transfer to "Standby" does not occur, go to Problem 5 in Section 3.3.
5. If transfer to "Standby" occurs, but retransfer back to "Utility" does not occur when utility source voltage is restored, go to Problem 6 in Section 3.3.

TEST 42 - TRY A MANUAL START

DISCUSSION:

The first step in troubleshooting for an "engine won't crank" condition is to determine if the problem is peculiar to automatic operations only or if the engine won't crank manually either.

PROCEDURE:

1. On the generator panel, set the Auto-Off-Manual switch to OFF.
2. Set the generator main line circuit breaker to its OFF or open position.
3. Set the generator Auto-Off-Manual switch to MANUAL.
   a. The engine should crank cyclically through it's "crank-rest" cycles until it starts.
   b. Let the engine stabilize and warm up for a few minutes after it starts.

RESULTS:

1. If the engine cranks manually but does not crank automatically, go to Test 43.
2. If the engine does not crank manually, proceed to Problem 9 in the "Troubleshooting Flow Charts".

TEST 43- TEST AUTO-OFF-MANUAL SWITCH

DISCUSSION:

When the Auto-Off-Manual switch is set to AUTO position, battery voltage (12 volts DC) is delivered to the circuit board via Wire 15A, the closed switch terminal, Wire 15A, and Pin 10 of the circuit board connector. This voltage is needed to operate the circuit board.

Setting the switch to its "Manual" position delivers battery voltage to the circuit board for its operation. In addition, when the switch is set to "Manual", 12 volts DC is supplied to the circuit board via Pin 11 of the board, Wire 239, the closed switch contacts, Wire 17 and Pin 9 of the circuit board connector.

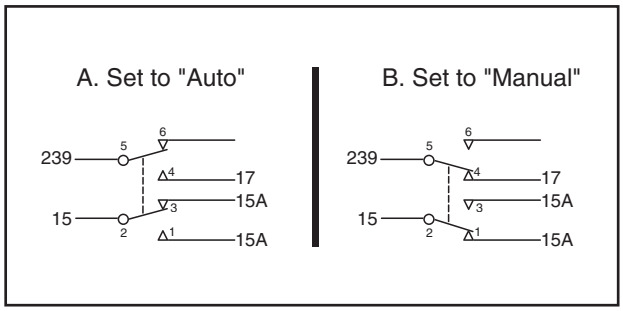


Figure 1. Schematic of Auto-Off-Manual Switch

PROCEDURE:

Disconnect all wires from switch terminals, to prevent interaction. Then, use a volt-ohm-milliammeter (VOM) to test for continuity across switch terminals as shown in the following chart. Reconnect all wires and verify correct positions when finished.

TERMINALS	SWITCH POSITION	READING
2 and 3	AUTO MANUAL OFF	CONTINUITY INFINITY INFINITY
2 and 1	AUTO MANUAL OFF	INFINITY CONTINUITY INFINITY
5 and 6	AUTO MANUAL OFF	CONTINUITY INFINITY INFINITY
5 and 4	AUTO MANUAL OFF	INFINITY CONTINUITY INFINITY

RESULTS:

1. Replace Auto-Off-Manual switch, if defective.
2. For Problem 8 Only: If the switch passes the tests, verify the remote not auto dip switch is set to OFF on the circuit board (see Figure 3, Section 4.1) then proceed to Test 44.
3. For Problem 9 Only: If the switch passes the tests, proceed to Test 60.

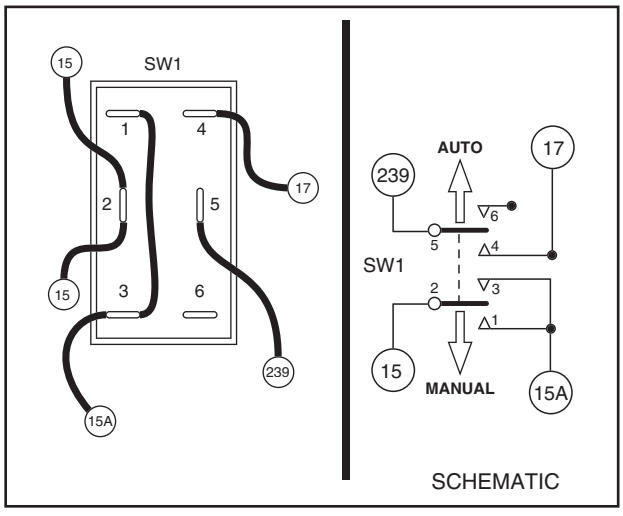


Figure 2. Auto-Off-Manual Switch Test Points

TEST 44- CHECK WIRE 15/15A/17/239 VOLTAGE

DISCUSSION:

The circuit board will not turn on unless battery voltage is available to the board via wire 15, the Auto-Off-Manual switch and Wire 15A. If battery voltage is not available, automatic or manual operation will not be possible.

Battery voltage is available to wire 17 from pin location 11 of the J1 connector on the circuit board. When the Auto-Off-Manual switch is in the MANUAL position, wire 239 supplies battery voltage to pin location 9 of the circuit board, and engine cranking occurs.

PROCEDURE:

(For Problem 1 flow chart, do Steps 1-5 and Step 9 only)

(For Problem 2 flow chart, do all steps)

1. Set a VOM to measure DC voltage.
2. Connect the positive (+) test lead to the Auto-Off-Manual switch Terminal 2, Wire 15. Connect the negative (-) test lead to a clean frame ground. Battery voltage should be measured (See Figure. 2).
3. Connect the positive (+) test lead to the Auto-Off-Manual switch terminal 1, Wire 15A. Connect the negative (-) test lead to a clean frame ground. Set the Auto-Off-manual switch to MANUAL. Battery voltage should be measured.
4. Connect the positive (+) test lead to Pin location 12 Wire 15 at the J1 connector on the circuit board. Connect the negative (-) test lead to a clean frame ground. Battery voltage should be measured.
5. Connect the positive (+) test lead to pin location 10, wire 15A at the J1 connector on the circuit board. Connect the negative test lead to a clean frame ground. Set the Auto-Off-Manual switch to the MANUAL position. Battery voltage should be measured. Repeat Step 5. This time set the Auto-Off-Manual switch to AUTO. Battery voltage should be measured.
6. Connect the positive (+) test lead to pin location 9, wire 239 at the J1 connector on the circuit board. Connect the negative (-) test lead to a clean frame ground. Set the Auto-Off-Manual switch to the MANUAL position. Battery voltage should be measured. If battery voltage is measured, stop and proceed to results. If battery voltage is not measured, proceed to Step 7.
7. Connect the positive (+) test lead to the Auto-Off-Manual

switch Terminal 4, Wire 17/178. Connect the negative (-) test lead to a clean frame ground. Battery voltage should be measured.

8. Connect the positive (+) test lead to Pin location 11, wire 17 at the J1 connector on the circuit board. Connect the negative (-) test lead to a clean frame ground. Battery voltage should be measured.
9. Set a VOM to measure resistance "R x 1" scale. Connect one meter test lead to a clean frame ground. Connect the other test lead to Pin location 13, Wire 0 at the J1 connector on the circuit board. Continuity should be measured.

RESULTS:

1. No battery voltage in Step 2. Go to test 45 or repair/replace Wire 15 from F1 to SW1.
2. No battery voltage in Step 3. Go to Test 43 or repair or replace Wire 15A from Terminal 1 to Terminal 3 of SW1.
3. No battery voltage in Step 4. Verify Step 2 and repair or replace wire 15 from SW1 to J1 connector.
4. No battery voltage in Step 5. Go to Test 43 or repair or replace Wire 15A from SW1 to J1 connector.
5. If battery voltage is available in Step 8 but not in Step 7, repair or replace Wire 17 from SW1 to J1 connector.
6. If battery voltage is available in Step 7 but not in Step 6, go to Test 43.
7. If continuity is not measured in Step 9, repair or replace Wire 0 between the J1 connector and the 8-tab ground terminal.
8. If battery voltage is available in Steps 1-5 but not in Step 8 of Problem 2 flow chart, replace or repair the circuit board.
9. If battery voltage is available in Steps 1-5 for Problem 1 flow chart, replace the circuit board.

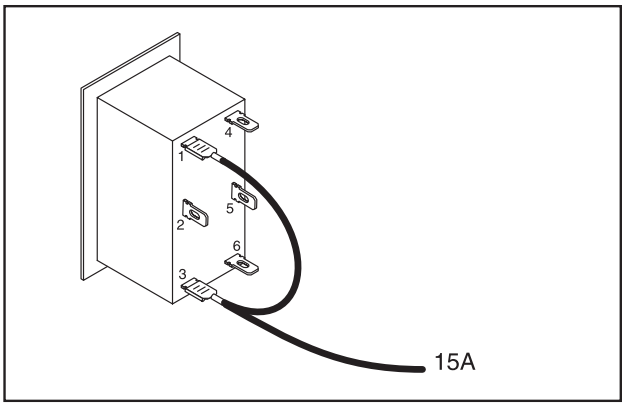


Figure 3. Wires 15A

TEST 45- CHECK 15 AMP FUSE

DISCUSSION:

The 15 amp fuse is located on the generator console. A blown fuse will prevent battery power from reaching the circuit board, with the same result as setting the Auto-Off-Manual switch to OFF.

PROCEDURE:

Remove the 15 amp fuse (F1) by pushing in on fuse holder cap and turning the cap counterclockwise. Inspect the fuse visually and with a VOM for an open condition.

RESULTS:

1. If the fuse if good, go on to Test 46.
2. If the fuse is bad, it should be replaced. Use only an identical 15 amp replacement fuse.
3. If fuse continues to blow, go to Problem 16.

TEST 46- CHECK BATTERY

DISCUSSION:

Battery power is used to (a) crank the engine and (b) to power the circuit board. Low or no battery voltage can result in failure of the engine to crank, either manually or during automatic operation.

PROCEDURE:

A. Inspect Battery Cables:

1. Visually inspect battery cables and battery posts.
2. If cable clamps or terminals are corroded, clean away all corrosion.
3. Install battery cables, making sure all cable clamps are tight. The red battery cable from the starter contactor (SC) must be securely attached to the positive (+) battery post; the black cable from the frame ground stud must be tightly attached to the negative (-) battery post.

B. Test Battery State of Charge:

1. Use an automotive type battery hydrometer to test battery state of charge.
2. Follow the hydrometer manufacturer's instructions carefully. Read the specific gravity of the electrolyte fluid in all battery cells.
3. If the hydrometer does not have a "percentage of charge" scale, compare the reading obtained to the following:
   a. An average reading of 1.260 indicates the battery is 100% charged.
   b. An average reading of 1.230 means the battery is 75% charged.
   c. An average reading of 1.200 means the battery is 50% charged.

d. An average reading of 1.170 indicates the battery is 25% charged.

C. Test Battery Condition:

1. If the difference between the highest and lowest reading cells is greater than 0.050 (50 points), battery condition has deteriorated and the battery should be replaced.
2. However, if the highest reading cell has a specific gravity of less than 1.230, the test for condition is questionable. Recharge the battery to a 100 percent state of charge, then repeat the test for condition.

RESULTS:

1. Remove the battery and recharge with an automotive battery charger, if necessary.
2. If battery condition is bad, replace the battery with a new one.

TEST 47 - CHECK WIRE 56 VOLTAGE

DISCUSSION:

During an automatic start or when starting manually, a crank relay (K1) on the circuit board should energize. Each time the crank relay energizes, the circuit board should deliver 12 volts DC to a starter contactor relay(SCR) and the engine should crank. This test will verify (a) that the crank relay on the circuit board is energizing, and (b) that circuit board action is delivering 12 volts DC to the starter contactor relay.

PROCEDURE:

1. Connect the positive (+) test probe of a DC voltmeter (or VOM) to the Wire 56 connector of the starter contactor relay (SCR, on models with v-twin engines) or the starter contactor (SC, on models with single cylinder engines). Connect the common (-) test probe to frame ground.
2. Observe the meter. Then, actuate the Auto-Off-Manual switch to MANUAL position.
   a. The circuit board crank and run relays should energize.
   b. The meter should indicate battery voltage.
3. Insert the positive (+) meter test lead into Pin 5 of the circuit board connector J1. Connect the common (-) test lead to a clean frame ground. Then, repeat Step 2.
   a. The circuit board's crank and run relays should energize.
   b. The meter should read battery voltage.

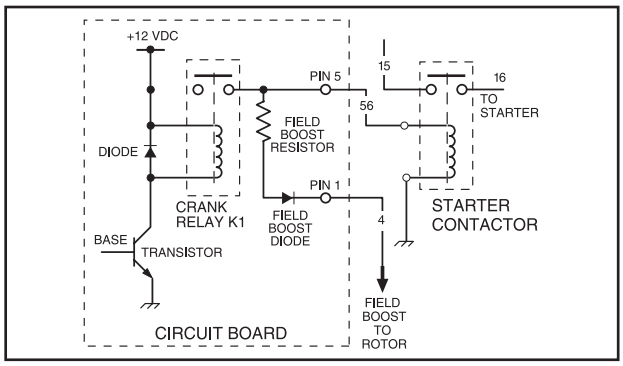


Figure 4. The Wire 56 Circuit

RESULTS:

1. If battery voltage is indicated in Step 3, but not in Step 2, Wire 56 (between the circuit board and starter contactor relay or starter contactor) is open. Repair or replace this wire as required.
2. If battery voltage is not indicated in Step 3, go to Test 43.
3. If battery voltage is indicated in both Steps 2 and 3, but engine does not crank, go on to Test 49.

TEST 48- TEST STARTER CONTACTOR RELAY (V-TWIN ONLY)

DISCUSSION:

The starter contactor relay (SCR) located in the control panel must be energized for cranking to occur. Once the SCR is energized, it's normally open contacts will close and battery voltage will be available to Wire 16 and to the starter contactor (SC).

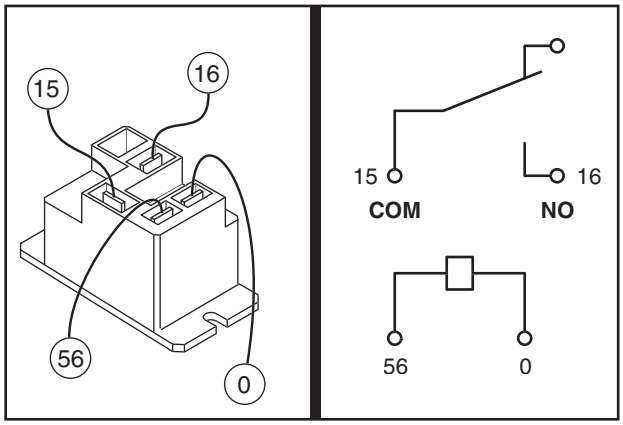


Figure 5. The Starter Contactor Relay

PROCEDURE:

1 Set a VOM to measure DC voltage.

2. Connect the positive (+) meter test lead to the Wire 13 connector. Connect the negative (-) meter test lead to a clean frame ground. Battery voltage should be measured.
3. Connect the positive (+) meter test lead to the Wire 16 connector. Connect the negative (-) meter test lead to a clean frame ground.
4. Set the Auto-Off-Manual switch to MANUAL. Observe the meter reading. Battery voltage should measured. If battery voltage is not measured, proceed to Step 5.
5. Set the VOM to it's "R x 1" scale to measure ohms.
6. Connect one test lead to the Wire 0 connector. Connect the other test lead to a clean frame ground. CONTINUITY should be measured.

RESULTS:

1 If battery voltage is not measured in Step 2, repair or replace wiring between starter contactor relay and fuse (F2).
2. If battery voltage is not measured in Step 4 and CONTINUITY is measured in Step 6, replace the starter contactor relay.
3. If battery voltage is measured in Step 4. proceed to Test 49.

TEST 49- TEST STARTER CONTACTOR

DISCUSSION:

The starter contactor (SC) must energize and its heavy duty contacts must close or the engine will not crank. This test will determine if the starter contactor is in working order.

PROCEDURE:

Carefully inspect the starter motor cable that runs from the battery to the starter motor. Cable connections must be clean and tight. If connections are dirty or corroded, remove the cable and clean cable terminals and terminal studs. Replace any cable that is defective or badly corroded.

Use a DC voltmeter (or a VOM) to perform this test. Test the starter contactor as follows:

1. Connect the positive (+) meter test lead to the starter contactor stud (to which the red battery cable connects). Connect the common (-) meter test lead to a clean frame ground. Battery voltage (12 volts DC) should be indicated.
2. Now, connect the positive (+) meter test lead to the starter contactor stud to which the starter motor cable attaches (see Figure 6 or 7). Connect the common (-) test lead to frame ground.

a. No voltage should be indicated initially.
b. Set the Auto-Off-Manual switch to MANUAL. The meter should now indicate battery voltage as the starter contactor energizes.

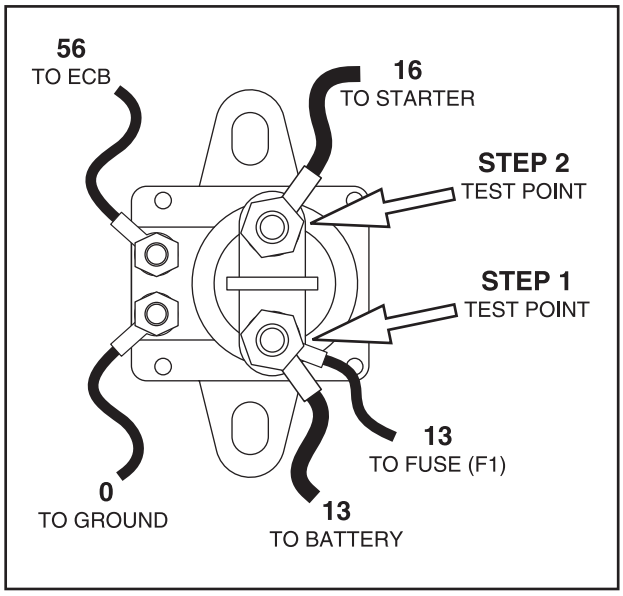


Figure 6. The Starter Contactor (Single Cylinder Units)

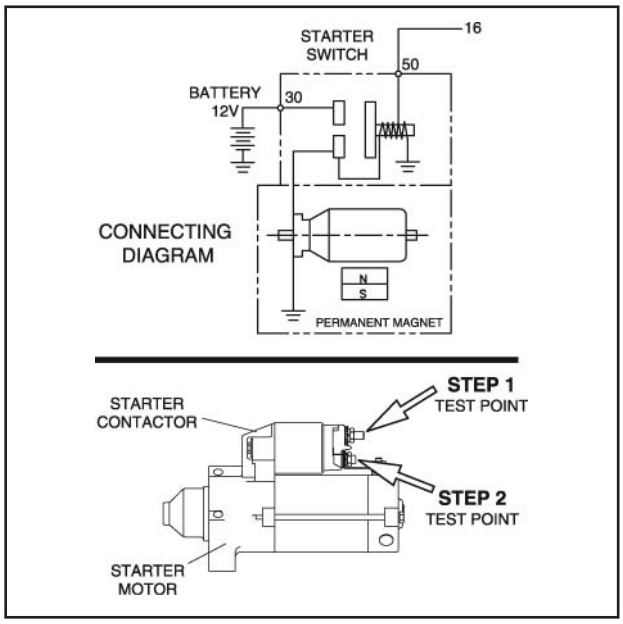


Figure 7. The Starter Contactor (V-twin Units)

RESULTS:

1. If battery voltage was indicated in Step 1, but not in Step 2b, replace the starter contactor.
2. If battery voltage was indicated in Step 2b, but the engine did not crank, go on to Test 50.

TEST 50- TEST STARTER MOTOR

CONDITIONS AFFECTING STARTER MOTOR PERFORMANCE:

1. A binding or seizing condition in the starter motor bearings.
2. A shorted, open or grounded armature.
   a. Shorted, armature (wire insulation worn and wires touching one another). Will be indicated by low or no RPM.
   b. Open armature (wire broken) will be indicated by low or no RPM and excessive current draw.
   c. Grounded armature (wire insulation worn and wire touching armature lamination or shaft). Will be indicated by excessive current draw or no RPM.
3. A defective starter motor switch.
4. Broken, damaged or weak magnets.
5. Starter drive dirty or binding.

DISCUSSION:

Test 47 verified that circuit board action is delivering DC voltage to the starter contactor relay (SCR). Test 48 verified the operation of the SCR. Test 49 verified the operation of the starter contactor (SC). Another possible cause of an "engine won't crank" problem is a failure of the starter motor.

PROCEDURE:

The battery should have been checked prior to this test and should be fully charged.

Set a VOM to measure DC voltage (12 VDC). Connect the meter positive (+) test lead to the starter contactor stud which has the small jumper wire connected to the starter. Connect the common (-) test lead to the starter motor frame.

Set the Start-Stop Switch to its "START" position and observe the meter. Meter should Indicate battery voltage, starter motor should operate and engine should crank.

RESULTS:

1. If battery voltage is indicated on the meter but starter motor did not operate, remove and bench test the starter motor (see following test).
2. If battery voltage was indicated and the starter motor tried to engage (pinion engaged), but engine did not crank, check for mechanical binding of the engine or rotor.

If engine turns over slightly, go to Test 62 “Check and Adjust Valves.” Compression release on single cylinder engines may not be working, or mechanical binding is occurring.

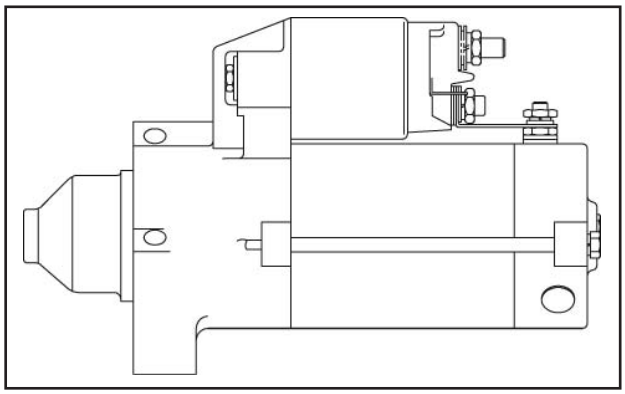


Figure 8. Starter Motor (V-Twin Engines)

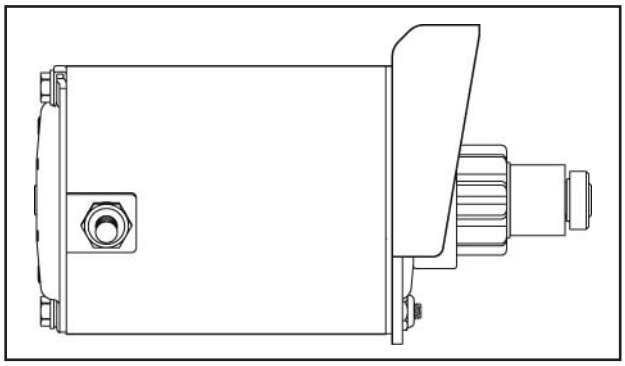


Figure 9. Starter Motor (Single Cylinder Engines)

CHECKING THE PINION:

When the starter motor is activated, the pinion gear should move and engage the flywheel ring gear. If the pinion does not move normally, inspect the pinion for binding or sticking.

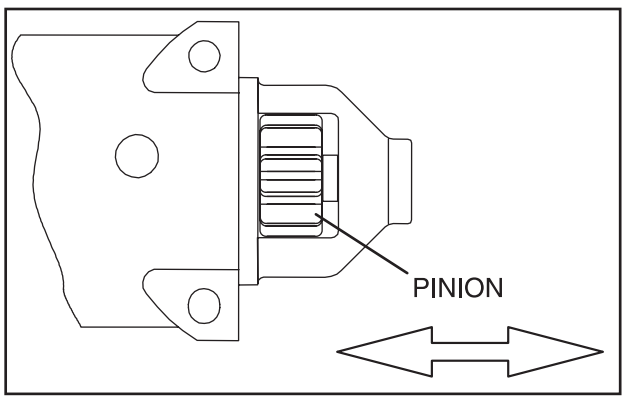


Figure 10. Check Pinion Gear Operation (V-Twin)

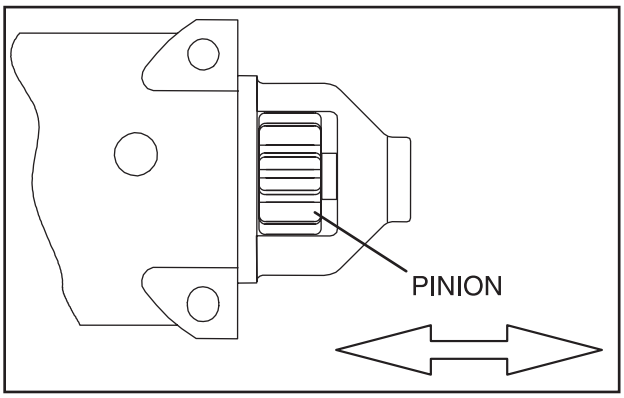


Figure 11. Check Pinion Gear Operation (Single Cylinder)

TOOLS FOR STARTER PERFORMANCE TEST:

The following equipment may be used to complete a performance test of the starter motor:

- A clamp-on ammeter.
- A tachometer capable of reading up to 10,000 rpm.
- A fully charged 12-volt battery.

MEASURING CURRENT:

To read the current flow, in AMPERES, a clamp-on ammeter may be used. This type of meter indicates current flow through a conductor by measuring the strength of the magnetic field around that conductor.

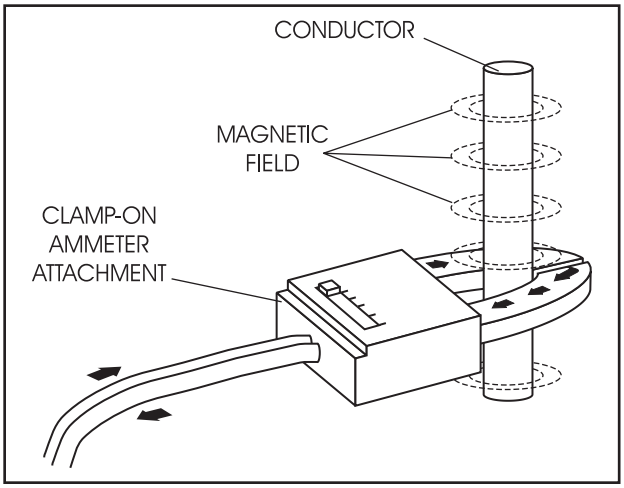


Figure 12. Clamp-On Ammeter

TACHOMETER:

A tachometer is available from your Generac Power Systems source of supply. Order as P/N 042223. The tachometer measures from 800 to 50,000 RPM, Figure 13.

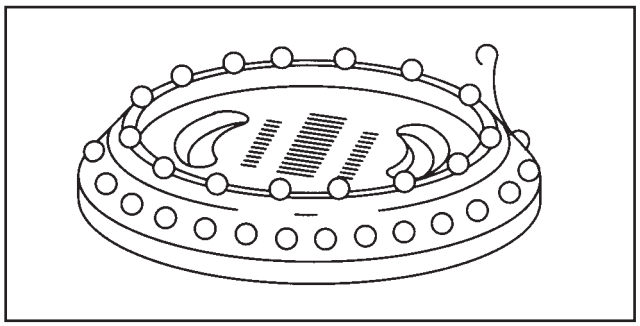


Figure 13. Tachometer

TEST BRACKET:

A starter motor test bracket may be made as shown in Figure 14. A growler or armature tester is available from an automobile diagnostic service supplier.

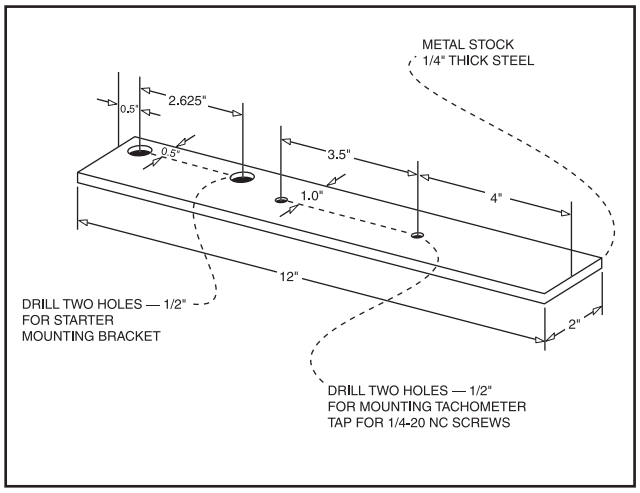


Figure 14. Test Bracket

REMOVE STARTER MOTOR:

It is recommended that the starter motor be removed from the engine when testing starter motor performance. Assemble starter to test bracket and clamp test bracket in vise, Figure 15.

TESTING STARTER MOTOR:

1. A fully charged 12 volt battery is required.
2. Connect jumper cables and clamp-on ammeter as shown in Figure 15.
3. With the starter motor activated (jump the terminal on the starter contactor to battery voltage), note the reading on the clamp-on ammeter and on the tachometer (rpm).

Note: Take the reading after the ammeter and tachometer are stabilized, approximately 2-4 seconds.

4. A starter motor in good condition will be within the following specifications:

	Single Cylinder	V-twin
Minimum rpm	**800**	**4500**
Maximum Amps	**9**	**50**

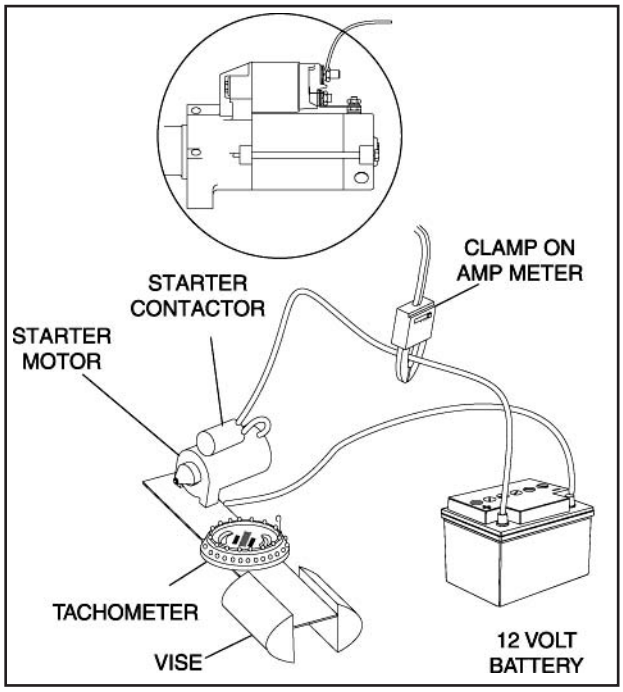


Figure 15. Testing Starter Motor Performance

TEST 51 - CHECK FUEL SUPPLY AND PRESSURE

DISCUSSION:

The air-cooled prepackaged generator was factory tested and adjusted using natural gas as a fuel. If desired, LP (propane) gas may be used. However, when changing over to propane, some minor adjustments are required. The following facts apply:

- An adequate gas supply and sufficient fuel pressure must be available or the engine will not start.
- Minimum recommended gaseous fuel pressure at the generator fuel inlet connection is 11 inches water column (6.38 ounces per square inch).
- Maximum gaseous fuel pressure at the generator fuel inlet connection is 14 inches water column (8 ounces per square inch).
- When propane gas is used, only a "vapor withdrawal" system may be used. "This type of system utilizes the gas that form above the liquid fuel the vapor pressure must be high enough engine operation.
- The gaseous fuel system must be properly tested for leaks following installation and periodically thereafter. No leakage is permitted. Leak test methods must comply strictly with gas codes.

DANGER: GASEOUS FUELS ARE HIGHLY EXPLOSIVE. DO NOT USE FLAME OR HEAT TO TEST THE FUEL SYSTEM FOR LEAKS. NATURAL GAS IS LIGHTER THAN AIR, TENDS TO SETTLE IN HIGH PLACES. LP (PROPANE) GAS IS HEAVIER THAN AIR, TENDS TO SETTLE IN LOW AREAS. EVEN THE SLIGHTEST SPARK CAN IGNITE THESE GASES AND CAUSE AN EXPLOSION.

PROCEDURE:

A water manometer or a gauge that is calibrated in "ounces per square inch" may be used to measure the fuel pressure. Fuel pressure at the inlet side of the fuel solenoid valve should be between 11 - 14 inches water column as measured with a manometer, or 6.38-8.00 ounces per square inch as measure with a pressure gauge.

The fuel pressure can be checked using a pressure tester kit (Generac p/n 0C7977). See Figure 16 for the gas pressure test point on the fuel regulator.

NOTE: Where a primary regulator is used to establish fuel inlet pressure, adjustment of that regulator is usually the responsibility of the fuel supplier or the fuel supply system installer.

RESULTS:

1. If fuel supply and pressure are adequate, but engine will not start, go on to Test 53.
2. If generator starts but runs rough or lacks power, repeat the above procedure with the generator running and under load. The fuel system must be able to maintain 11”-14” water column at all load requirements. If proper fuel supply and pressure is maintained, go to Test 55.

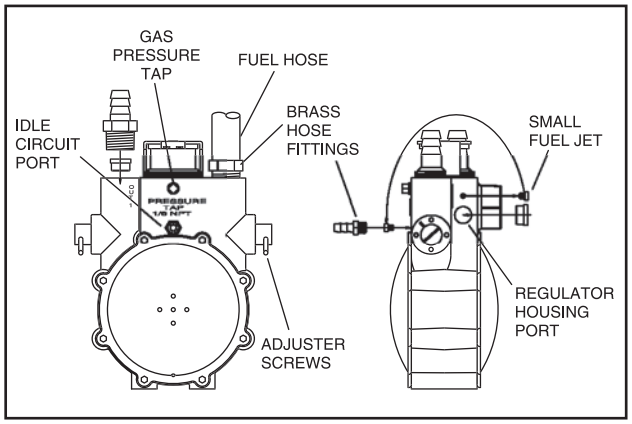


Figure 16. Air Cooled Engine Fuel System

TEST 52 - TEST FUEL SOLENOID

Note: This test is for fuel regulators equipped with idle circuit port only. See Figure 16. These units have an additional 1/4" fuel hose.

DISCUSSION:

When the Fuel Solenoid (FS) is energized, gas pressure is available internally to the on demand Fuel Regulator. Gas pressure will then be available to the idle circuit port of the Fuel Regulator.

PROCEDURE:

1. Disconnect Wire 56 from the starter contactor relay (SCR). This will disable the unit from cranking. For single cylinder units, disconnect from the starter contactor (SC) and isolate it from ground.
2. Remove the fuel hose from the idle circuit port barbed fitting.
3. Attach a manometer (Generac P/N 0C7977) to the idle circuit port barbed fitting.
4. Set the Auto-Off-Manual switch to MANUAL. The engine will not crank, but gas pressure should be observed on the manometer at 11"-14" of water column.
5. Set the Auto-Off-Manual switch to OFF. Remove the manometer. Re-attach the fuel hose to the idle circuit port barbed fitting. Re-connect Wire 56 to the starter contactor relay or starter contactor.

RESULTS:

1. If gas pressure was measured, proceed to Test 55.
2. If gas pressure was not measured, replace the fuel solenoid (FS).

TEST 53 - CHECK CIRCUIT BOARD WIRE 14 OUTPUT

DISCUSSION:

During any cranking action, the circuit board's crank relay (K1) and run relay (K2) both energize simultaneously. When the run relay energizes, its contacts close and 12 volts DC is delivered to Wire 14 and to a fuel solenoid. The solenoid energizes open to allow fuel flow to the engine. This test will determine if the circuit board is working properly.

PROCEDURE:

1. Set the Auto-Off-Manual switch to OFF.
2. Connect the positive (+) test lead of a DC voltmeter (or VOM) into Pin 7 (Wire 14) of the circuit board connector J1. Connect the common (-) test lead to frame ground.
3. While observing the meter, set the Auto-Off-Manual switch to MANUAL.
   a. The circuit board's crank and run relays should energize and the engine should crank and start.
   b. The meter should indicate battery voltage.
   c. If battery voltage is indicated, proceed to Step 4. If battery voltage is NOT indicated, proceed to Test 53 results.
4. Disconnect Wire 14 at the Fuel Solenoid (FS).
   a. Connect the positive (+) test lead to Wire 14. Connect the negative test lead to a clean frame ground. Set the Auto-Off-Manual switch to MANUAL. Battery voltage should be measured. If battery voltage is indicated, proceed to Step 5.
   b. Connect the positive (+) test lead to Wire 14 at the 4-tab terminal block in the control panel, see Figure 17. Connect the negative (-) test lead to frame ground. While observing the meter, set the Auto-Off-Manual switch to MANUAL. Battery voltage should be measured.

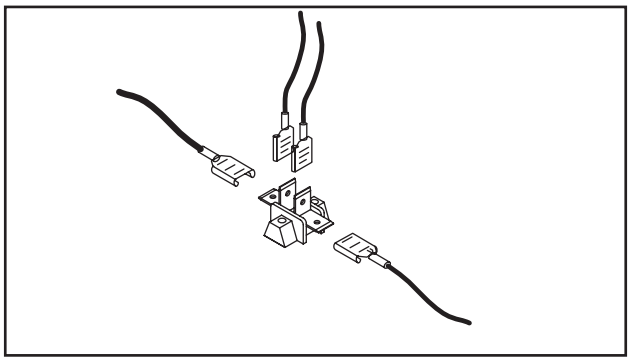


Figure 17. 4-Tab Terminal Block

5. Set the VOM to it's "R x 1" scale.
6. Disconnect Wire 0 from the Fuel Solenoid (FS). Connect one test lead to Wire 0 and the other test lead to a clean frame ground. CONTINUITY should be measured.

RESULTS:

1. If the engine cranks but does not start and battery voltage was not measured in Step 3, replace the circuit board.
2. If the engine cranks and battery voltage was measured in Step 3, but there was no battery voltage in Step 4(a), repair or replace Wire 14 between 4-tab terminal block and the Fuel Solenoid (FS).
3. If the engine cranks and battery voltage was measured in step 3 and no battery voltage is measured in step 4b, repair or replace Wire 14 between the J1 connector on the circuit board and the 4-tab terminal block.
4. If the engine cranks but does not start and battery voltage was measured in Steps 2, 3 and 4, and CONTINUITY was not measured in Step 6, repair or replace Wire 0 between the Control Panel ground

connection and the Fuel Solenoid terminal. If CONTINUITY was measured in Step 6, proceed to Test 52 or test 54 depending on the model.

TEST 54 - CHECK FUEL SOLENOID

DISCUSSION:

In Test 53, if battery voltage was delivered to Wire 14, the fuel solenoid should have energized open. This test will verify whether or not the fuel solenoid is operating.

Fuel Solenoid Nominal Resistance 27-33 ohms.

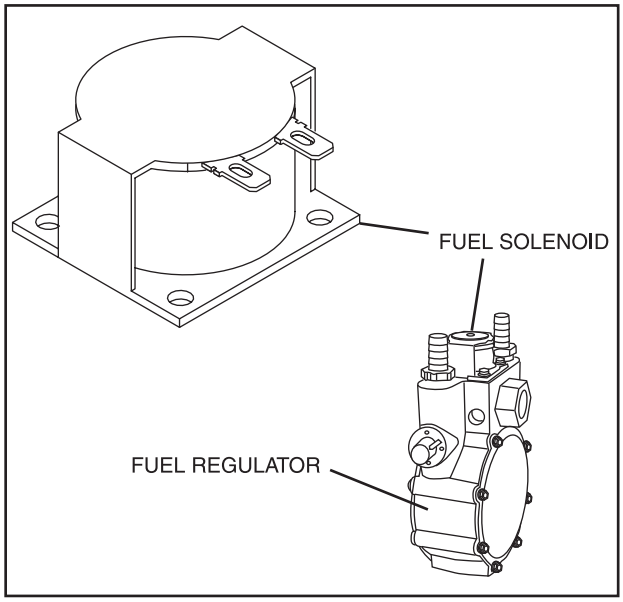


Figure 18. The Fuel Solenoid (FS)

PROCEDURE:

1. Disconnect Wire 56 from the starter contactor relay (SCR). This will disable the unit from cranking. For single cylinder units, disconnect from the starter contactor (SC) and isolate it from ground.
2. Place one hand on the Fuel Solenoid (FS). Cycle the Auto-Off-Manual switch from MANUAL to OFF. You should be able to feel the solenoid actuate as well as hear it actuate. If a small screwdriver is placed on the solenoid and then gently pulled away, a magnetic field should be felt.
3. Set the Auto-Off-Manual switch to OFF. Reconnect Wire 56 to starter contactor relay or starter contactor.

RESULTS:

1. If solenoid actuates, go to Test 55.
2. Replace the solenoid if it does not actuate.

TEST 55 - CHECK FOR IGNITION SPARK

DISCUSSION:

If the engine cranks but will not start, perhaps an ignition system failure has occurred. A special "spark tester" (Generac P/N 0C5969) can be used to check for ignition spark.

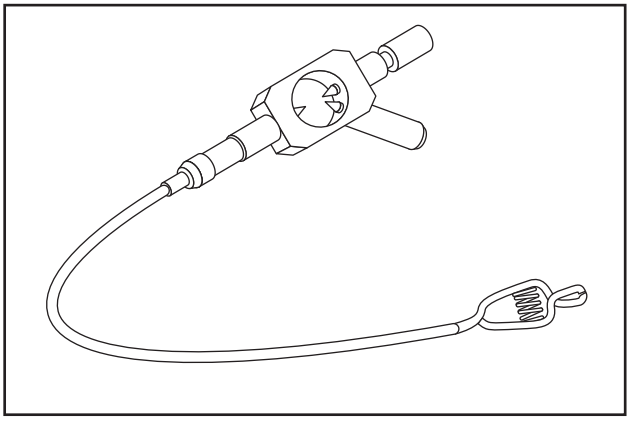


Figure 19. Spark Tester

PROCEDURE:

1. Remove spark plug leads from the spark plugs (Figure 20).
2. Attach the clamp of the spark tester to the engine cylinder head.

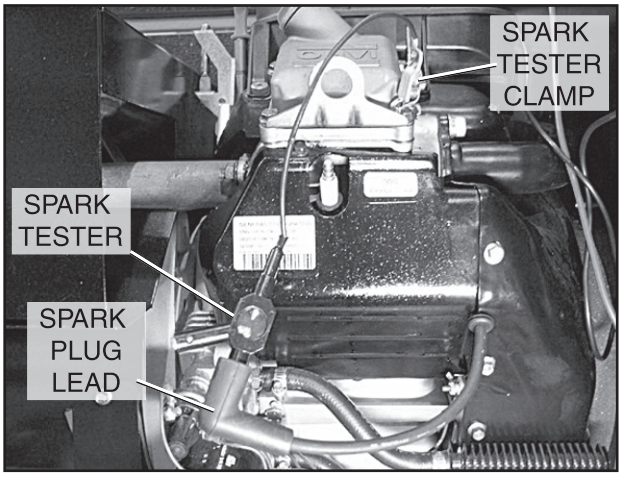


Figure 20. Checking Ignition Spark

3. Attach the spark plug lead to the spark tester terminal.
4. Crank the engine while observing the spark tester. If spark jumps the tester gap, you may assume the engine ignition system is operating satisfactorily.

NOTE: The engine flywheel must rotate at 350 rpm (or higher) to obtain a good test of the solid state ignition system.

To determine if an engine miss is ignition related, connect the spark tester in series with the spark plug wire and the spark plug (Figure 21). Then, crank and start the engine. A spark miss will be readily apparent. If spark jumps the spark tester gap regularly but the engine miss continues, the problem is in the spark plug or in the fuel system.

NOTE: A sheared flywheel key may change ignition timing but sparking will still occur across the spark tester gap.

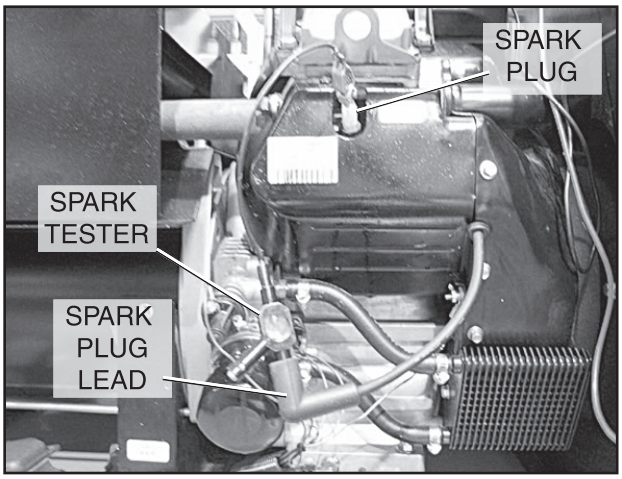


Figure 21. Checking Engine Miss

RESULTS:

1. If no spark or very weak spark occurs, go to Test 58.
2. If sparking occurs but engine still won't start, go to Test 56.
3. When checking for engine miss, if sparking occurs at regular intervals but engine miss continues, go to Test 16.
4. When checking for engine miss, if a spark miss is readily apparent, go to Test 59.

TEST 56 - CHECK SPARK PLUGS

DISCUSSION:

If the engine will not start and Test 55 indicated good ignition spark, perhaps the spark plug(s) are fouled or otherwise damaged. Engine miss may also be caused by defective spark plug(s).

PROCEDURE:

1. Remove spark plugs and clean with a penknife or use a wire brush and solvent.
2. Replace any spark plug having burned electrodes or cracked porcelain.
3. Set gap on new or used spark plugs to 0.030 inch for single cylinder engines and 0.020 inch for v-twin engines.

RESULTS:

1. Clean, re-gap or replace spark plugs as necessary.
2. If spark plugs are good, go to Test 62.

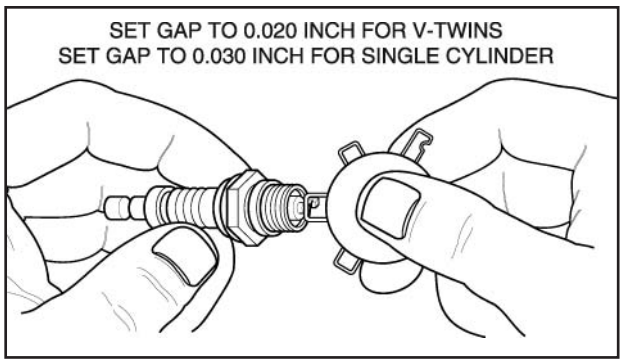


Figure 22. Checking Spark Plug Gap

TEST 57- CHECK ENGINE COMPRESSION

DISCUSSION:

Lost or reduced engine compression can result in (a) failure of the engine to start, or (b) rough operation. One or more of the following will usually cause loss of compression:

- Blown or leaking cylinder head gasket.
- Improperly seated or sticking-valves.
- Worn Piston rings or cylinder. (This will also result in high oil consumption).

NOTE: For the single cylinder engine, the minimum allowable compression pressure for a cold engine is 60 psi.

NOTE: It is extremely difficult to obtain an accurate compression reading without special equipment. For that reason, compression values are not published for the V-Twin engine. Testing has proven that an accurate compression indication can be obtained using the following method.

PROCEDURE:

1. Remove both spark plugs.
2. Insert a compression gauge into either cylinder.

3. Crank the engine until there is no further increase in pressure.
4. Record the highest reading obtained.
5. Repeat the procedure for the remaining cylinder and record the highest reading.

RESULTS:

The difference in pressure between the two cylinders should not exceed 25 percent. If the difference is greater than 25 percent, loss of compression in the lowest reading cylinder is indicated.

Example 1: If the pressure reading of cylinder #1 is 65 psi and of cylinder #2, 60 psi, the difference is 5 psi. Divide "5" by the highest reading (65) to obtain the percentage of 7.6 percent.

Example 2: *No. 1 cylinder reads 75 psi; No. 2 cylinder reads 55 psi. The difference is 20 psi. Divide "20" by "75" to obtain "26.7" percent. Loss of compression in No. 2 cylinder is indicated.*

If compression is poor, look for one or more of the following:

- Loose cylinder head bolts.
- Failed cylinder head gasket.
- Burned valves or valve seats.
- Insufficient valve clearance.
- Warped cylinder head.
- Warped valve stem.
- Worn or broken piston ring(s).
- Worn or damaged cylinder bore.
- Broken connecting rod.
- Worn valve seats or valves.

TEST 58 - CHECK SHUTDOWN WIRE

DISCUSSION:

Circuit board action during shutdown will ground Wire 18. Wire 18 is connected to the Ignition Magneto(s). The grounded magneto will not be able to produce spark.

PROCEDURE:

1. On v-twin generators, remove Wire 18 from the stud located above the oil cooler. On single cylinder generators, disconnect Wire 18 at the bullet connector.
2. Perform Test 55.
3. If spark now occurs with Wire 18 removed, check for a short to ground. Set the Auto-Off-Manual switch to OFF. Remove the 17 pin connector J1 from the circuit board.
4. Set a VOM to measure resistance. Connect one test lead to Wire 18 from the control panel. Connect the other test lead to a clean frame ground. INFINITY should be measured.
5. Reconnect the J1 connector to the circuit board.
6. Set a VOM to measure resistance. Connect one test lead to Wire 18 from the control panel. Connect the other test lead to a clean frame ground. Set the Auto-Off-Manual switch to MANUAL. During cranking the meter should read infinity.

RESULTS:

1. If INFINITY was not measured in Step 4, repair or replace shorted ground Wire 18 between the J1 connector from the circuit board to the stud or bullet connector.
2. If INFINITY was not measured in Step 6 during cranking, replace the circuit board and retest for spark.
3. If ignition spark still has not occurred, proceed to Test 59.

TEST 59 - CHECK AND ADJUST IGNITION MAGNETOS

DISCUSSION:

In Test 55, a spark tester was used to check for engine ignition. If sparking or weak spark occurred, one possible cause might be the ignition magneto(s). This test consists of adjusting the air gap between the ignition magneto(s) and the flywheel. The flywheel and flywheel key will also be checked during this test.

PROCEDURE:

Note: The air gap between the ignition magneto and the flywheel on single cylinder engines is non-adjustable. Proceed directly to Steps 15,16 and 17 for single cylinder engines. For V-twin engines, proceed as follows.

1. See Figure 23. Rotate the flywheel until the magnet is under the module (armature) laminations.
2. Place a 0.008-0.012 inch (0.20-0.30mm) thickness gauge between the flywheel magnet and the module laminations.
3. Loosen the mounting screws and let the magnet pull the magneto down against the thickness gauge.
4. Tighten both mounting screws.
5. To remove the thickness gauge, rotate the flywheel.
6. Repeat the above procedure for the second magneto.

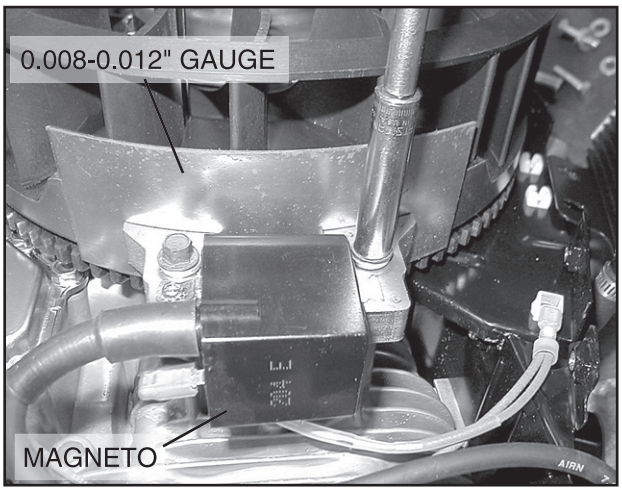


Figure 23. Setting Ignition Magneto (Armature) Air Gap

7. Repeat Test 55 and check for spark across the spark tester gap.
8. If air gap was not out of adjustment, test ground wires.
9. Set the VOM to the diode test position. The meter will display forward voltage drop across the diode. If the voltage drop is less than 0.7 volts, the meter will “Beep” once as well as display the voltage drop. A continuous tone indicates CONTINUITY (shorted diode). An incomplete circuit (open diode) will be displayed as “OL.”
10. Disconnect the engine wire harness from the ignition magnetos and stud connector (Figure 24).

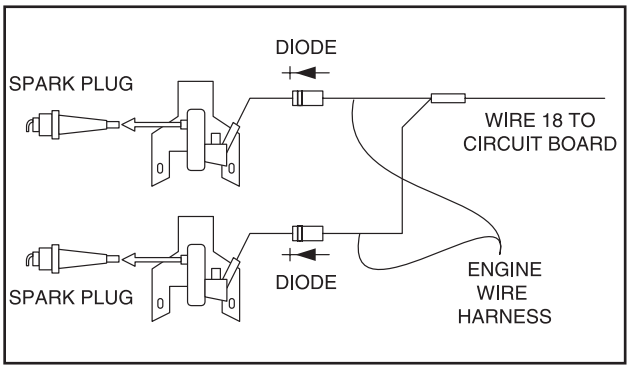


Figure 24. Engine Ground Harness

SWITCH ON	TURNED OFF	CAUSE
Engine Runs On One Cylinder	Shuts Off OK	1 Closed Diode
Engine Runs (Both Cylinders)	Only One Cylinder Shuts Off	1 Open Diode
Won't Run (No Spark)		2 Closed Diodes
Engine Runs (Both Cylinders)	Engine Won't Shut Off	2 Open Diodes

Figure 25. Diode Failure Diagnosis

11. Connect the positive (+) test lead to Connector ”A” (as shown in Figure 26). Connect the negative (-) test lead to Connector “B.”
    a. If meter “Beeps” once and displays voltage drop, then the diode is good.
    b. If the meter makes a continuous tone, the diode is bad (shorted) and the harness must be replaced.
    c. If the meter displays “OL,” the diode is defective (open) and the harness must be replaced.

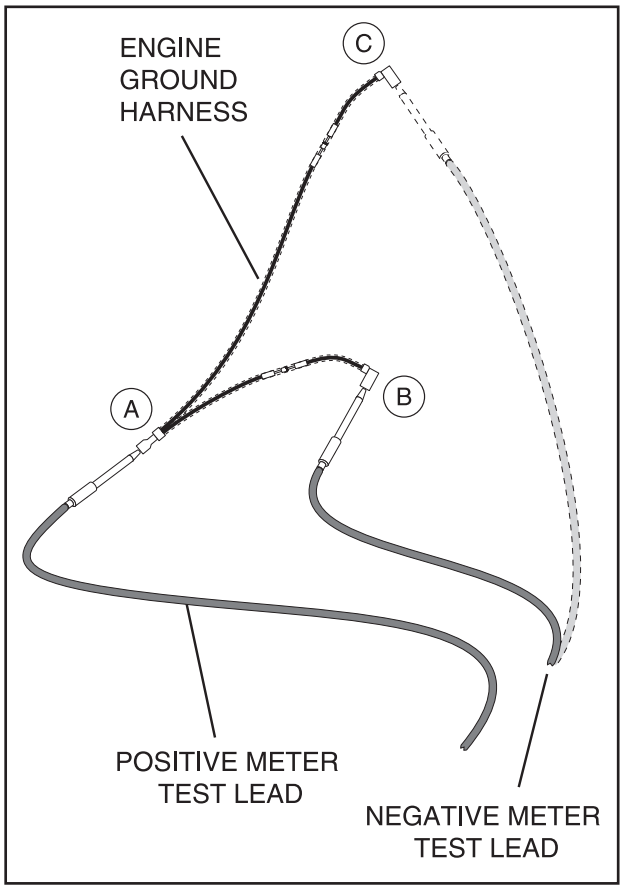


Figure 26. Engine Ground Harness Test Points

12. Now repeat Step 11 with the negative meter test lead connected to Connector "C" (Figure 26).
13. Now check the flywheel magnet by holding a screwdriver at the extreme end of its handle and with its point down. When the tip of the screwdriver is moved to within 3/4 inch (19mm) of the magnet, the blade should be pulled in against the magnet.
14. Now check the flywheel key. The flywheel's taper is locked on the crankshaft taper by the torque of the flywheel nut. A keyway is provided for alignment only and theoretically carries no load.

Note: If the flywheel key becomes sheared or even partially sheared, ignition timing can change. Incorrect timing can result in hard starting or failure to start.

15. As stated earlier, the armature air gap is fixed for single cylinder engine models and is not adjustable. Visually inspect the armature air gap and hold down bolts.
16. Disconnect the shutdown ground wire from the armature and retest for spark, Test 55.
17. Perform Steps 13 and 14.

RESULTS:

If sparking still does not occur after adjusting the armature air gap, testing the ground wires and performing the basic flywheel test, replace the ignition magneto(s).

TEST 60- CHECK OIL PRESSURE SWITCH AND WIRE 86

DISCUSSION:

If the oil pressure switch contacts have failed in their closed position, the engine will probably crank and start. However, shutdown will then occur within about 5 (five) seconds. If the engine cranks and starts, then shuts down almost immediately with a LOP fault light, the cause may be one or more of the following:

- Low engine oil level.
- Low oil pressure.
- A defective oil pressure switch.

If the oil pressure switch contacts have failed open or Wire 86 does not have continuity to ground at starting, the engine will not crank. If the engine does not crank, the cause may be one of the following:

- A defective oil pressure switch stuck open.
- An open Wire 86 to Circuit Board.

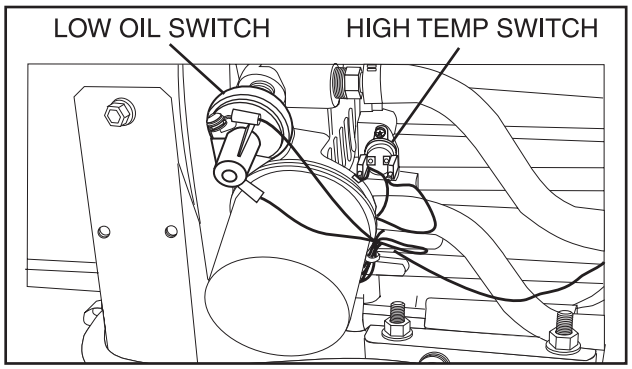


Figure 27. Oil Pressure Switch

PROCEDURE:

Note: For Problem 9 Flow Chart, perform Steps 3a, 4 and 5 only. For Problem 12 Flow Chart perform all steps.

1. Check engine crankcase oil level.
   a. Check engine oil level.
   b. If necessary, add the recommended oil to the dipstick FULL mark. DO NOT OVERFILL ABOVE THE FULL MARK.
2. With oil level correct, try starting the engine.
   a. If engine still cranks and starts, but then shuts down, go to Step 3.
   b. If engine does not crank go to Step 6.
   c. If engine cranks and starts normally, discontinue tests.
3. Do the following:
   a. Disconnect Wire 86 and Wire 0 from the oil pressure switch terminals. Remove the switch and install an oil pressure gauge in its place.
   b. Connect Wire 86 to Wire 0 for starting purposes only. After engine starts, remove Wire 86 from Wire 0.
   c. Start the engine while observing the oil pressure reading on gauge.
   d. Note the oil pressure.
      (1) Normal oil pressure is approximately 35-40 psi with engine running. If normal oil pressure is indicated, go to Step 4 of this test.
      (2) If oil pressure is below about 4.5 psi, shut engine down immediately. A problem exists in the engine lubrication system.

Note: The oil pressure switch is rated at 10 psi for v-twin engines, and 8 psi for single cylinder engines.

4. Remove the oil pressure gauge and reinstall the oil pressure switch. Do NOT connect Wire 86 or Wire 0 to the switch terminals.

a. Set a VOM to its "R x 1" scale and zero the meter.

b. Connect the VOM test leads across the switch terminals. With engine shut down, the meter should read CONTINUITY.

c. Connect Wire 86 to Wire 0 for starting purposes only. After engine starts, remove Wire 86 from Wire 0.

d. Crank and start the engine. The meter should read INFINITY.

5. Perform Steps 4a and 4b. If INFINITY is measured with the engine shutdown, replace the LOP switch.

6. Set a VOM to it's "R x 1" scale.

a. Connect one test lead to Wire 86 (disconnected from LOP). Connect the other test lead to Pin Location 2 (Wire 86) of the J1 connector at the Circuit Board. CONTINUITY should be measured. If CONTINUITY is not measured, repair or replace Wire 86 between the LOP switch and the J1 Connector.

b. Connect one test lead to Wire 0 (disconnected from LOP). Connect the other test lead to a clean frame ground. Continuity should be measured. If continuity is NOT measured repair or replace Wire 0 between the LOP and and the ground terminal connection on the engine mount.

7. If the LOP switch tests good in Step 4 and oil pressure is good in Step 3 but the unit still shuts down with a LOP fault, check Wire 86 for a short to ground. Set a VOM to it's "R x 1" scale. Disconnect the J1 Connector from the circuit board. Remove Wire 86 from the LOP switch. Connect one test lead to Wire 86. Connect the other test lead to a clean frame ground. INFINITY should be measured. If CONTINUITY is measured, repair or replace Wire 86 between the LOP switch and the J1 Connector.

RESULTS:

1. If switch tests good for Problem 9, proceed to Test 44.

2. Replace switch if it fails the test.

TEST 61- CHECK HIGH OIL TEMPERATURE SWITCH

DISCUSSION:

If the temperature switch contacts have failed in a closed position, the engine will not crank or start. If it tries to start, it will immediately fault out on "Overtemp." If the unit is in an overheated condition, the switch contacts will close at 284ºF. This will normally occur from inadequate airflow through the generator.

PROCEDURE:

1. Verify that the engine has cooled down (engine block is cool to the touch). This will allow the contacts in the High Oil Temperature Switch to close.

2. Check the installation and area surrounding the generator. There should be at least three feet of clear area around the entire unit. Make sure that there are no obstructions preventing incoming and outgoing air.

3. Disconnect Wire 85 and Wire 0 from the High Oil Temperature Switch.

4. Set a VOM to measure resistance. Connect the test leads across the switch terminals. The meter should read INFINITY.

5. If the switch tested good in Step 4, and a true over-temperature condition has not occurred, check Wire 85 for a short to ground. Remove Connector J2 (5-pin) from the circuit board. Set the VOM to measure resistance. Connect one test lead to Wire 85 (disconnected from High Oil Temperature Switch). Connect the other test lead to a clean frame ground. INFINITY should be measured.

TESTING HIGH OIL TEMPERATURE SWITCH:

6. Remove the High Oil Temperature Switch.

7. Immerse the sensing tip of the switch in oil as shown in Figure 28, along with a suitable thermometer.

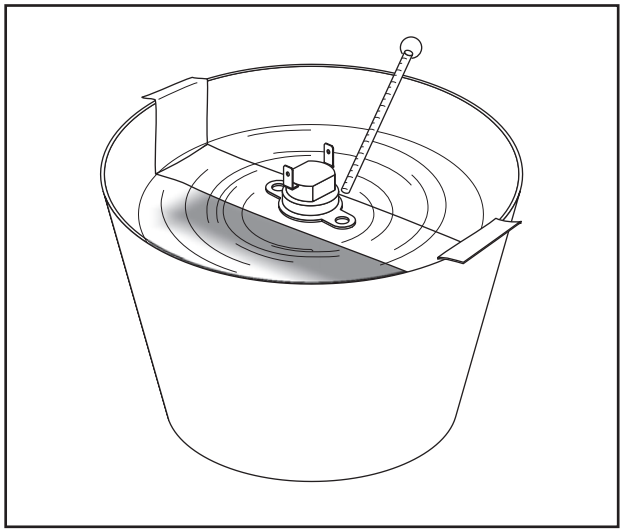


Figure 28. Testing the Oil Temperature Switch

8. Set a VOM to measure resistance. Then, connect the VOM test leads across the switch terminal and the switch body. The meter should read INFINITY.

9. Heat the oil in the container. When the thermometer reads approximately 274°-294° F. (134°-146° C.), the VOM should indicate CONTINUITY.

RESULTS:

1. If the switch fails Step 4, or Steps 8-9, replace the switch.
2. If INFINITY was not measured in Step 5, repair or replace Wire 85 between the Circuit Board and the High Oil Temperature Switch.

TEST 62 - CHECK AND ADJUST VALVES

DISCUSSION:

Improperly adjusted valves can cause various engine related problems including, but not limited to, hard starting, rough running and lack of power. The valve adjustment procedure for both the single cylinder and the V-twin engines is the same.

PROCEDURE (INTAKE AND EXHAUST):

Make sure that the piston is at Top Dead Center (TDC) of it's compression stroke (both valves closed). The valve clearance should be 0.05-0.1mm (0.002-0.004 in) cold.

Check and adjust the valve to rocker arm clearance as follows:

1. Remove the four (4) screws from the rocker cover.
2. Remove the rocker cover and rocker cover gasket.

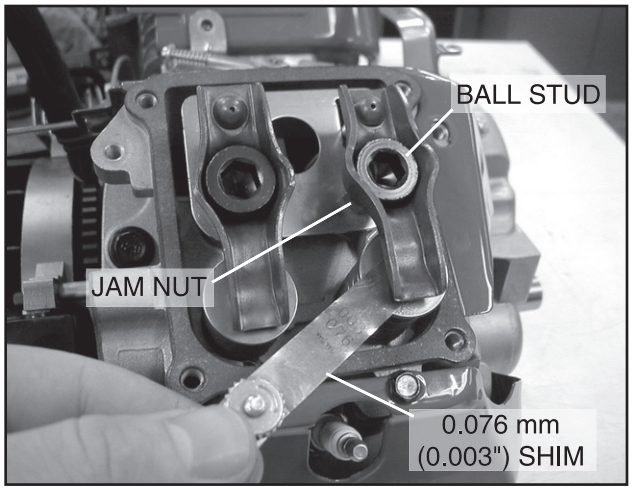


Figure 29

3. Loosen the rocker arm jam nut. Use a 10mm allen wrench to turn the pivot ball stud and check the clearance between the rocker arm and the valve stem with a flat feeler gauge (see Figure 29).
4. When the valve clearance is correct, hold the pivot ball stud with the allen wrench and tighten the rocker arm jam nut. Torque the jam nut to 174 inch pounds. After tightening the jam nut, recheck the valve clearance to make sure it did not change.
5. Re-install the rocker cover gasket, rocker cover and the four (4) screws.

RESULTS:

Adjust valve clearance as necessary, the retest.

TEST 63 - CHECK FUEL REGULATOR

DISCUSSION:

The fuel regulator is rarely the cause of a hard start or no start condition. The most common causes are insufficient fuel pressure supplied to the unit, or the adjustment screws on the fuel regulator being out of adjustment. The fuel regulator is an "ON DEMAND" type. During cranking and running, negative pressure from the airbox or carburetor unseats the fuel regulator diaphragms and allows fuel flow through the regulator.

PROCEDURE:

1. Turn off utility power to the main distribution panel in the house. This can be done by switching the service main breaker to the OFF or "Open" position.
2. Allow the generator to start. Before loading the generator, confirm that the No Load Frequency, with the roof open and the door off, is set to 63-63.5 Hz. Transfer load to emergency circuits.
3. Turn on appliances. lights, pumps, etc., that are on the emergency circuits in an attempt to fully load the generator. Be cautious not to overload the generator. Use the following chart as a guide:

Unit	120 Volts	240 Volts
7 kW	50.0 amps	25.0 amps
12 kW	100.0 amps	50.0 amps
13/15 kW	108.3/125.0 amps	54.1/62.5 amps

4. When full load has been achieved, connect a frequency meter to the output lugs of the generator main line circuit breaker.

   The fuel regulator is fitted with one (7 kW), or two (12 & 15 kW) adjustment screws. While watching the frequency meter, slowly turn the adjustment screw(s) clockwise or counterclockwise one at a time until highest frequency is read on the meter.

Note: Only limited adjustment is available between the set pins on 5fuel regulators. Under no circumstance should any of the pins be removed (see Figures 30 & 31).

5. When the highest frequency is reached, maximum power has been set. From this point turn the adjustment screw(s) 1/4 turn counterclockwise. The regulator is now set.

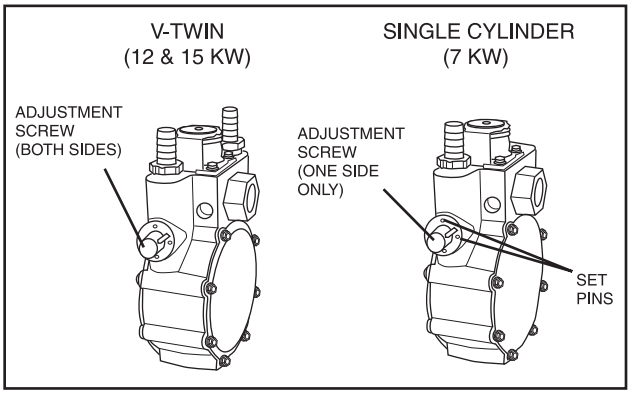


Figure 30

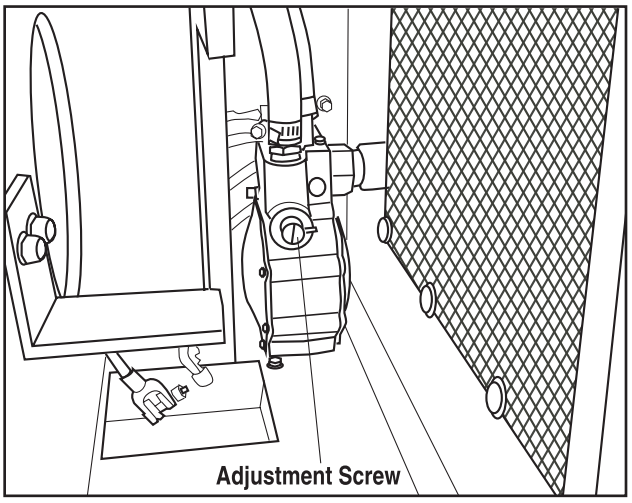


Figure 31

6. Turn utility power to the main distribution panel back on. This can be done by switching the service main breaker to the "ON" or closed position. Allow the generator to shut down.

⚠ WARNING ⚠

DO NOT MAKE ANY UNNECESSARY ADJUSTMENTS. FACTORY SETTINGS ARE CORRECT FOR MOST APPLICATIONS. HOWEVER, WHEN MAKING ADJUSTMENTS, BE CAREFUL TO AVOID OVERSPEEDING THE ENGINE.

TEST 64 - CHECK BATTERY CHARGE OUTPUT

DISCUSSION:

The battery charging system is a two amp trickle charge. It is capable of maintaining a charge on a functional battery. It is not intended to, nor capable of charging a completely dead battery.

The system will charge when utility source power is available to the generator or if the generator is running. The system consists of a transformer (TX), battery charge relay (BCR), battery charger (BC), and a battery charge winding. The BCR contacts allow AC voltage to the battery charger. When the BCR is de-energized, voltage from the TX is available to the battery charger. When the generator starts, Wire 14 energizes the BCR. This allows battery charge winding AC output to power the battery charger.

PROCEDURE:

1. Check the 5 amp fuse (F2).
2. Set the Auto-Off-Manual switch to OFF.

Note: Utility source voltage MUST be available to the generator.

3. Set a VOM to measure DC amps.
4. Disconnect Wire 13A (purple) from the 5 amp fuse (F2).
5. Connect the positive (+) test lead to Wire 13A, and connect the negative (-) test lead to the fuse (F2) terminal from which Wire 13A was removed. The VOM should measure 50 milliamps to 2.5 amps, depending upon the state of the charge of the battery.
6. Repeat Step 5. This time set the Auto-Off-Manual switch to MANUAL. Allow the generator to start and then measure the current again as in Step 5.

RESULTS:

Follow the Flow Chart in Section 4.3.

TEST 65 - CHECK TRANSFORMER (TX) VOLTAGE OUTPUT

DISCUSSION:

The Transformer (TX) is a “step down” type and has two functions. It supplies approximately 16 VAC to the control panel circuit board for utility sensing. It also supplies approximately 16 VAC to the battery charger for trickle charging. A defective transformer will:

a. not supply AC to the battery charger, and

b. not supply sensing voltage to the circuit board.

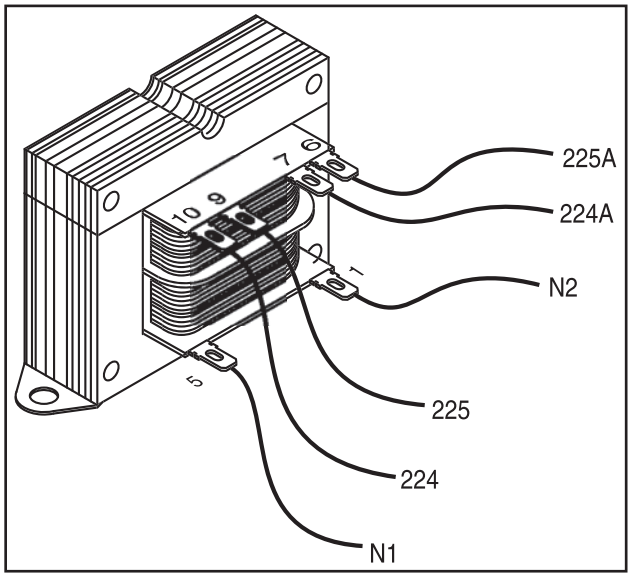


Figure 32. Transformer (TX)

PROCEDURE:

1. Set a VOM to measure AC voltage.
2. Connect one meter test lead to the Transformer (TX) Terminal 5, Wire N1. Connect the other meter test lead to the Transformer (TX) Terminal 1, Wire N2. Utility line-to-line voltage (240 VAC) should be measured.
3. Connect one meter test lead to the Transformer (TX) Terminal 6 with Wire 225A removed. Connect the other meter test lead to the Transformer (TX) Terminal 7 with Wire 224A removed. This output supplies power to the battery charger. The VOM should measure approximately 16 VAC.
4. Connect one meter test lead to the Transformer (TX) Terminal 9 with Wire 224 removed. Connect the other meter test lead to the Transformer (TX) Terminal 10 with Wire 224 removed. This AC output is used as utility sensing, and is supplied to the circuit board. The VOM should measure approximately 16 VAC.

RESULTS:

1. If line-to-line voltage was not measured in Step 2, go to Problem 7, Section 3.3.
2. If correct voltage was measured in Step 2, and no voltage was measured in Step 3, replace the Transformer.
3. If correct voltage was measured in Step 2, and no voltage was measured in Step 4, replace the Transformer.
4. If voltage output was correct for Step 3 and for Step 4, refer back to the Flow Chart (Section 4.3).

TEST 66 - CHECK AC VOLTAGE AT BATTERY CHARGER

DISCUSSION:

The battery charger needs to be supplied with approximately 16 VAC. When the generator is not running and utility source power is available, the battery charger still receives voltage from the Transformer (TX). When the generator is running, voltage is supplied to the battery charger from the battery charge winding.

PROCEDURE:

1. Set the Auto-Off-Manual switch to OFF.

Note: Utility source voltage MUST be available to the generator.

2. Set a VOM to measure AC voltage.
3. Disconnect the two pin connector (Wire 224B and Wire 225B) at the battery charger.
4. Connect one meter test lead to Wire 224B at the two pin connector. Connect the other test lead to Wire 225B at the two pin connector. Approximately 16 VAC should be measured.
5. Verify that the battery charge relay (BCR) is wired correctly (Figure 33).
6. Connect one meter test lead to Terminal 1, Wire 224A on the BCR. Connect the other test lead to Terminal 3, Wire 225A. Approximately 16 VAC should be measured.

RESULTS:

1. If voltage was not measured in Step 6, but was measured in Test 65, repair or replace Wire 224A and Wire 225B between the transformer (TX) and the battery charge relay (BCR).
2. If voltage was not measured in Step 4, go to Test 67.

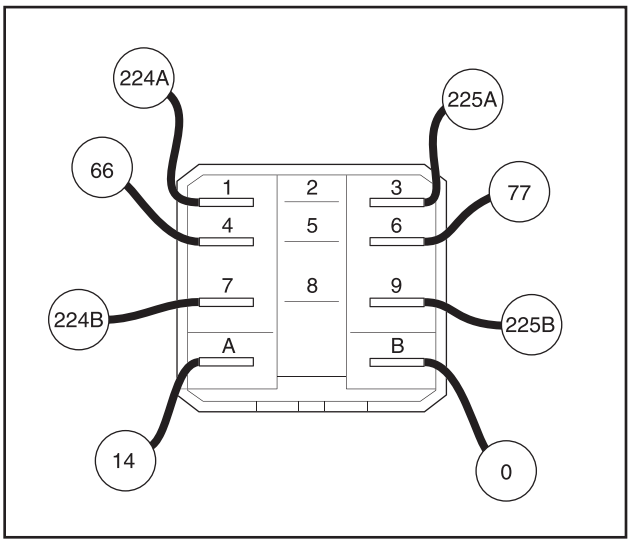


Figure 33. Battery Charge Relay Test Points

TEST 67 - CHECK BATTERY CHARGE RELAY (BCR)

DISCUSSION:

The battery charge relay is used to switch the AC source delivered to the battery charger. When the BCR is de-energized, the Normally Closed (NC) contacts deliver AC power from the transformer. When the BCR is energized by Wire 14, the Normally Open (NO) contacts close and battery charge winding AC source is delivered to the battery charger.

PROCEDURE:

1. See Figure 33. Disconnect all wires from the battery charge relay, to prevent interaction.
2. Set a VOM to its "R x 1" scale and zero the meter.
3. Follow the chart below and test each set of contacts. Connect the VOM test leads to the relay terminals indicated in the chart provided below.
4. To energize or de-energize the relay. Connect a jumper wire to a positive (+)12VDC source and to relay Terminal "A". Connect a jumper wire to the negative (-) 12VDC source and to relay Terminal "B". The relay will ENERGIZE. Disconnect the positive jumper from Terminal "A" of the relay and the relay will DE-ENERGIZE.

CONNECT VOM TEST LEADS ACROSS	DESIRED METER READING	
	ENERGIZED	DE-ENERGIZED
Terminals 6 and 9	Continuity	Infinity
Terminals 3 and 9	Infinity	Continuity
Terminals 4 and 7	Continuity	Infinity
Terminals 1 and 7	Infinity	Continuity

RESULTS:

1. Replace the battery charge relay if it fails any of the steps in this chart.
2. If the BCR tests good, but still does not function during generator operation, check Wire 14 and Wire 0 connected to the BCR.
   a. Set a VOM to measure DC volts. Disconnect Wire 14 from BCR Terminal “A.” Connect the positive (+) test lead to Wire 14. Connect the negative (-) test lead to a clean frame ground. Set the Auto-Off-Manual switch to MANUAL. Battery voltage should be measured. If battery voltage is not measured, repair or replace Wire 14 between the BCR and the 4-tab terminal block.
   b. If voltage was measured in “a,” set the VOM to measure resistance. Disconnect Wire 0 from BCR Terminal “B.” Connect one test lead to Wire 0. Connect the other test lead to a clean frame ground. CONTINUITY should be measured. If CONTINUITY was not measured, repair or replace Wire 0 between the BCR and the ground terminal.

TEST 68 - CHECK BATTERY CHARGE WINDING HARNESS

DISCUSSION:

This test will check the continuity of Wire 66 and Wire 77 between Connector C2 and the battery charge relay.

PROCEDURE:

1. Disconnect Connector C2 from the side of the control panel. See Figure 9, page 128 for connector location.
2. Disconnect Wire 66 from Terminal 6, and Wire 77 from Terminal 4 of the BCR.
3. Set a VOM to measure resistance.

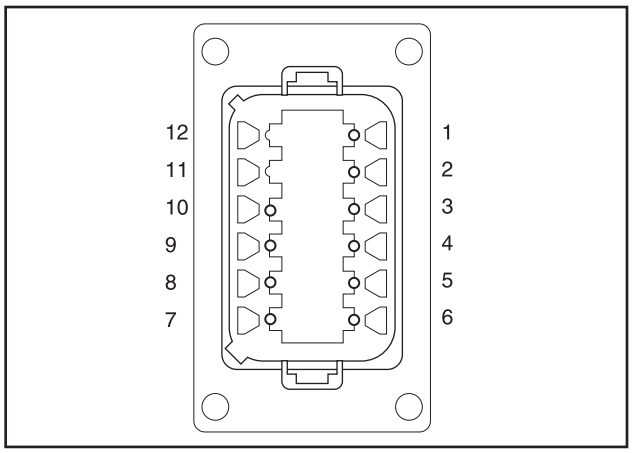


Figure 34. C2 Connector Pin Locations (Male Side)

4. Connect one test lead to Connector C2 Pin Location 1 (Wire 77). Connect the other test lead to the end of Wire 77 which was previously removed from the BCR. CONTINUITY should be measured.
5. Connect one test lead to Connector C2 Pin Location 2 (Wire 66). Connect the other test lead to the end of Wire 66 which was previously removed from the BCR. CONTINUITY should be measured.

RESULTS:

If CONTINUITY was not measured in Step 4 or Step 5, repair or replace defective wiring between Connector C2 and the battery charge relay.

TEST 69 - CHECK BATTERY CHARGER WIRING

DISCUSSION:

The three pin connector on the battery charger connects the charger to ground and to battery power.

PROCEDURE:

1. Set the Auto-Off-Manual switch to OFF.
2. Disconnect the three pin connector from the battery charger.
3. Set a VOM to measure resistance.
4. Connect one meter test lead to Wire 13A at the three pin connector. Connect the other test lead to Wire 13A at Fuse F2. CONTINUITY should be measured.
5. Connect one meter test lead to Wire 0 at the three pin connector. Connect the other test lead to the ground terminal. CONTINUITY should be measured.

RESULTS:

1. If CONTINUITY was not measured in Step 4, repair or replace Wire 13A between the battery charger and fuse F2.
2. If CONTINUITY was not measured in Step 5, repair or replace Wire 0 between the battery charger and frame ground.

TEST 70 - CHECK ENGINE RUN WINDING

DISCUSSION:

The engine run winding provides an AC input through Wire 66A to the circuit board. This input is used for overspeed sensing. If the input is not received by the circuit board, immediate shutdown will occur.

PROCEDURE:

1. Set the Auto-Off-Manual switch to OFF.
2. Set a VOM to measure resistance.
3. Disconnect Connector C2 from the side of the control panel.
4. Disconnect Connector J1 from the circuit board.
5. Connect one meter test lead to Connector C2 Pin Location 3 (Wire 66A). Connect the other test lead to Connector J1 Pin Location 8 (Wire 66A). CONTINUITY should be measured.
6. Connect one test lead to Connector C2 Pin Location 4 (Wire 55). Connect the other test lead to a clean frame ground. CONTINUITY should be measured.
7. Re-connect connector C2 to the control panel, and re-connect connector J1 to the circuit board.
8. Set a VOM to measure AC Voltage.
9. Connect the positive meter test lead to Pin Location 8, Wire 66A of the J1 Connector on the circuit board. Connect the negative meter test lead to the ground terminal. Set the Auto-Off-Manual switch to MANUAL. When the generator starts observe the voltage output on the VOM. AC voltage should be 8-12 VAC.
10. Set VOM to measure frequency. 62- 63 HZ should be measured.

RESULTS:

1. If CONTINUITY is not measured in Step 5, repair or replace Wire 66A between Connector C2 and Connector J1 at the circuit board.
2. If CONTINUITY was not measured in Step 6, repair or replace Wire 55 between Connector C2 and the ground terminal.
3. If CONTINUITY was measured in both Step 5 and Step 6, go to Test 7.
4. If AC voltage is not correct in Step 9, proceed to Test 7. If frequency is not correct adjust no load frequency and re-test.

TEST 71 - CHECK N1 AND N2 VOLTAGE

DISCUSSION:

Loss of utility source voltage to the generator will initiate a startup and transfer by the generator. Testing at the control panel terminal strip will divide the system in two, thereby reducing troubleshooting time.

PROCEDURE:

Note: Verify that Utility Source Voltage is present.

1. Set the Auto-Off-Manual switch to OFF.
2. Set a VOM to measure AC voltage.
3. Connect one test lead to Wire N1 at the terminal strip in the generator control panel. Connect the other test lead to Wire N2. Utility line-to-line voltage should be measured.

RESULTS:

1. If voltage was measured in Step 3, go to Test 65.
2. If voltage was not measured in Step 3, go to Test 28.

TEST 72 - CHECK UTILITY SENSING VOLTAGE AT THE CIRCUIT BOARD

DISCUSSION:

If the generator starts and transfer to “STANDBY” occurs in the automatic mode, even though an acceptable “UTILITY” source voltage is available from the Transformer (TX), the next step is to determine if that sensing voltage is reaching the circuit board.

PROCEDURE:

1. Set the Auto-Off-Manual switch to OFF.
2. Disconnect Connector J1 from the circuit board.
3. Set a VOM to measure AC voltage.
4. Connect one meter test lead to Pin Location J1-14 (Wire 225). Connect the other test lead to Pin Location J1-15 (Wire 224). Approximately 14-16 VAC should be measured.

RESULTS:

1. If voltage was measured in Step 4, replace the circuit board.
2. If voltage was NOT measured in Step 4, repair or replace Wire 224 and/or No. Wire 225 between Transformer (TX) and Circuit Board Connector J1.

TEST 73 - TEST SET EXERCISE SWITCH

DISCUSSION:

If the Set Exercise Switch (SW2) fails closed, the unit will start when in AUTO. In normal operation the Normally Open contacts close when the switch is depressed. This will ground Wire 351 and reset the exercise time.

PROCEDURE:

1. Set a VOM to measure resistance.
2. Disconnect Wire 351 and Wire 0 from the Set Exercise Switch (SW2).
3. Connect one meter test lead to one terminal of SW2. Connect the other test lead to the remaining terminal of SW2. The meter should read INFINITY.
4. With the meter test leads connected to SW2, depress and hold the switch activated. The meter should read CONTINUITY.

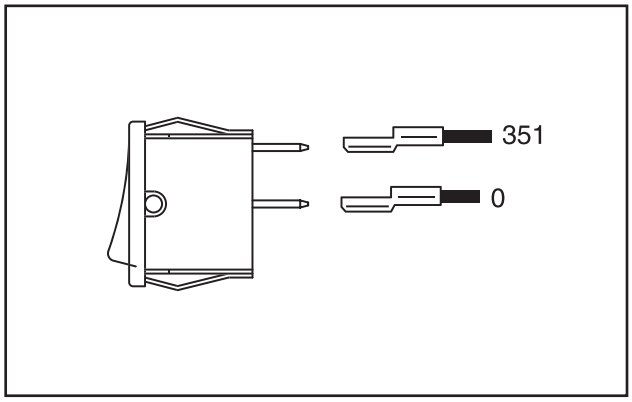


Figure 35. The Set Exercise Switch

5. Disconnect the five pin connector (J2) from the circuit board.

6. Connect one meter test lead to Wire 351 (previously removed from SW2). Connect the other meter test lead to Pin Location J3 (Wire 351). CONTINUITY should be measured.
7. Connect one meter test lead to Wire 351 (previously removed from SW2). Connect the other meter test lead to the ground terminal. INFINITY should be measured.
8. Connect one meter test lead to Wire 0 (previously removed from SW2). Connect the other meter test lead to the ground terminal. CONTINUITY should be measured.

RESULTS:

1. If the Set Exercise Switch (SW2) fails Step 3 or Step 4, replace the switch.
2. If CONTINUITY was NOT measured in Step 6, OR if it WAS measured in Step 7, repair or replace Wire 351 between SW2 and Connector J2.
3. If CONTINUITY was NOT measured in Step 8, repair or replace Wire 0 between SW2 and the ground terminal.

TEST 74 - CHECK REMOTE START WIRING (IF EQUIPPED)

DISCUSSION:

On some earlier models a remote start connection was available. If these two wires are connected together while the generator is in "AUTO," the generator will start.

PROCEDURE:

1. Set the Auto-Off-Manual switch to OFF.
2. Set a VOM to measure resistance.
3. Disconnect the 17-pin connector (J1) from the circuit board.
4. If the remote start connections have been used, disconnect the customer wires from the terminal connector at Wire 178 and Wire 183.
5. Connect one meter test lead to Wire 178 at the terminal connector. Connect the other meter test lead to Wire 183 at the terminal connector. INFINITY should be measured.
6. If the remote start connections have been used, connect the meter test leads across customer supplied wiring. If CONTINUITY is measured, customer supplied circuit is causing startup.

RESULTS:

1. If CONTINUITY was measured in Step 5, a short exists between Wire 178 and Wire 183. Repair or replace Wire 178 and/or Wire 183 between terminal connector and SW1.

TEST 75 - CHECK BATTERY VOLTAGE CIRCUIT

DISCUSSION:

If the 15 amp fuse blows immediately after replacement, Wire 15 should be checked for a fault.

PROCEDURE:

1. Set the Auto-Off-Manual switch to OFF.
2. Disconnect the 17-pin connector (J1) from the circuit board.
3. Set a VOM to measure resistance.
4. Disconnect Wire 15 from the fuse holder (F1).
5. Connect one meter test lead to Wire 15 (removed from fuse holder in previous step). Connect the other meter test lead to the ground terminal. INFINITY should be measured.

RESULTS:

1. If CONTINUITY was measured in Step 5, repair or replace Wire 15 between the fuse holder (F1) and SW1, or between SW1 and Connector J1.
2. If INFINITY was measured in Step 5, replace the circuit board and retest.

TEST 76 - CHECK CRANKING AND RUNNING CIRCUITS

DISCUSSION:

This test will check all of the circuits that are "HOT" with battery voltage and which could cause the F1 Fuse to blow.

PROCEDURE:

1. Set a VOM to measure resistance.
2. Disconnect the 17-pin connector (J1) from the circuit board.
3. Connect one meter test lead to the ground terminal. Connect the other meter test lead to each of the following J1 Connector pin locations:

J1-4, Wire 194 — If CONTINUITY was measured, go to Step 4. Average nominal resistance reading: 110-120 ohms.

J1-5, Wire 56 — If CONTINUITY was measured, go to Step 5. Average nominal resistance reading V-twin (SCR): 150-160 ohms, Single Cylinder (SC): 4 ohms.

J1-10, Wire 15A — If CONTINUITY was measured, repair or replace shorted to ground Wire 15A between Connector J1 and switch SW1.

J1-7, Wire 14 — If CONTINUITY was measured, go to Step 6.

NOTE: (V-twins only) Disconnect Wire 16 from the Starter Contactor Relay (SCR). Connect one test lead to ground and the other test lead to Wire 16. Starter Contactor (SC) resistance should be measured (?? ohms). If continuity is measured, repair or replace shorted Starter Contactor or shorted Wire 16 to ground.

4. Disconnect Wire 194 from the terminal strip. Repeat Step 3 at Pin Location J1-4.
   a. If CONTINUITY was measured, Wire 194 is shorted to ground between Connector J1 and terminal strip.
   b. If INFINITY was measured, disconnect Wire 194 from the transfer switch terminal strip. Connect one meter test lead to the end of Wire 194 which was removed from the transfer switch terminal strip. Connect the other meter test lead to the ground terminal. If CONTINUITY was measured, Wire 194 is shorted to ground between the generator and the transfer switch.
      1) If INFINITY was measured, disconnect Wire 194 from the transfer relay (TR). Connect one meter test lead to the transfer relay terminal from which Wire 194 was previously removed. Connect the other test lead to Wire 23 at the transfer switch terminal strip. If CONTINUITY "ZERO RESISTANCE" was measured, replace the transfer relay. Normal coil resistance is approximately 113 ohms.
      2) If coil resistance of 113 ohms was measured, the short is in Wire 194 between the transfer relay and the terminal strip. Repair or replace Wire 194.
5. Disconnect Wire 56 From the starter contactor relay (SCR on V-twin) or the starter contactor (SC on single cylinder). Connect one meter test lead to the SCR or SC terminal from which Wire 56 was removed. Connect the other meter test lead to the ground terminal. If CONTINUITY or zero resistance was measured, replace the SCR or SC. Coil resistance for the SCR is 155 ohms. Coil resistance for the SC is 4 ohms. If coil resistance was measured, Wire 56 is shorted to ground between Connector J1 and the SCR or SC. Repair or replace the shorted wire.
6. Disconnect and isolate each Wire 14 from the 4-tab insulated terminal block. Repeat Step 3 for Pin Location J1-7. If CONTINUITY was measured, repair or replace Wire 14 between Connector J1 and the 4-tab terminal block. If INFINITY was measured, proceed as follows:
   a. Disconnect Wire 14 from the following: fuel solenoid (FS), battery charge relay (BCR) and hourmeter (HM) if equipped.
   b. Connect the negative (-) meter test lead to the ground terminal. Connect the positive (+) meter test lead to each of the listed components at the terminal from which Wire 14 was removed. If CONTINUITY or zero resistance was measured, the component has shorted to ground. Replace the component. The average nominal resistance value that should be measured for each component is:

      Battery Charge Relay (BCR) - 112 ohms

      Fuel Solenoid (FS) - 31 ohms

      Hourmeter (HM) - 2 Mega ohms to infinity
   c. If each component tests good, there is no short to ground. The fault exists in one of the Wire 14 wires. Connect one meter test lead to the ground terminal. Connect the other meter test lead to each Wire 14 individually (on the end removed from the BCR, FS or HM). The Wire 14 which measures CONTINUITY is shorted to ground. Repair or replace the affected wire between the component and the 4-tab terminal block.

TEST 77 - TEST EXERCISE FUNCTION

DISCUSSION:

The following parameters must be met in order for the weekly exercise to occur:

- Auto-Off-Manual switch (SW1) set to AUTO.
- Circuit board DIP Switch 2 (Remote Not Auto) set to OFF.

PROCEDURE:

1. Set the Auto-Off-Manual switch (SW1) to MANUAL. The generator should start. Set SW1 back to AUTO. Verify that SW1 has been in AUTO for weekly exercise to function.
2. Verify that DIP Switch 2 (Remote Not Auto) on the circuit board is set to the OFF position (see Figure 1, Section 1.6).

3. Hold the Set Exercise switch until the generator starts (approximately 10 seconds) and then release. The generator will start and run for approximately 12 minutes and then shutdown on it's own. The exerciser will then be set to start and run at that time of that day each week. If the unit does not start, go to Test 73. Retest after performing Test 73. If the generator still will not start, replace the circuit board. If the generator does not start after depressing the Set Exercise switch, wait one week and watch for exercise operation. If exercise fails to operate, replace the circuit board.

PART 5 OPERATIONAL TESTS

Air-cooled, Prepackaged Automatic Standby Generators

Models:
6 kW NG, 7 kW LP
12 kW NG, 12 kW LP
13 kW NG, 15 kW LP

TABLE OF CONTENTS

PART	TITLE
5.1	System Functional Tests

INTRODUCTION

Following home standby electric system installation and periodically thereafter, the system should be tested Functional tests of the system include the following:

- Manual transfer switch operation.
- System voltage tests.
- Generator Tests Under Load.
- Testing automatic operation.

Before proceeding with functional tests, read instructions and information on tags or decals affixed to the generator and transfer switch. Perform all tests in the exact order given in this section.

MANUAL TRANSFER SWITCH OPERATION

"V-TYPE" TRANSFER SWITCHES:

1. On the generator panel, set the Auto-Off-Manual switch to OFF.
2. Turn OFF the "Utility" power supply to the transfer switch using whatever means provided (such as a "Utility" main line circuit breaker).
3. Set the generator main line circuit breaker to OFF or "Open".

DANGER: BE SURE TO TURN OFF ALL POWER VOLTAGE SUPPLIES TO THE TRANSFER SWITCH BEFORE ATTEMPTING MANUAL OPERATION. FAILURE TO TURN OFF POWER VOLTAGE SUPPLIES TO THE TRANSFER SWITCH MAY RESULT IN DANGEROUS AND POSSIBLY LETHAL ELECTRICAL SHOCK.

4. Remove the manual transfer handle from the enclosure.
5. Place open end of the manual transfer handle over transfer switch operating lever.
6. To connect "Load" terminal lugs to the "Standby" power source, move, the handle upward.
7. To connect "Load" terminals to the Utility" power source, move the handle downward.
8. Actuate the switch to "Utility" and to MANUAL several times. Make sure no evidence of binding or interference is felt.
9. When satisfied that manual transfer switch operation is correct, actuate the main contacts to their "Utility" position ("Load" connected to the "Utility" power supply).

ELECTRICAL CHECKS

Complete electrical checks as follows:

1. Set the generator main circuit breaker to its OFF (or open) position.
2. Set the generator Auto-Off-Manual switch to the “OFF “ position.
3. Turn off all loads connected to the transfer switch terminals T1 and T2.
4. Turn on the utility power supply to the transfer switch

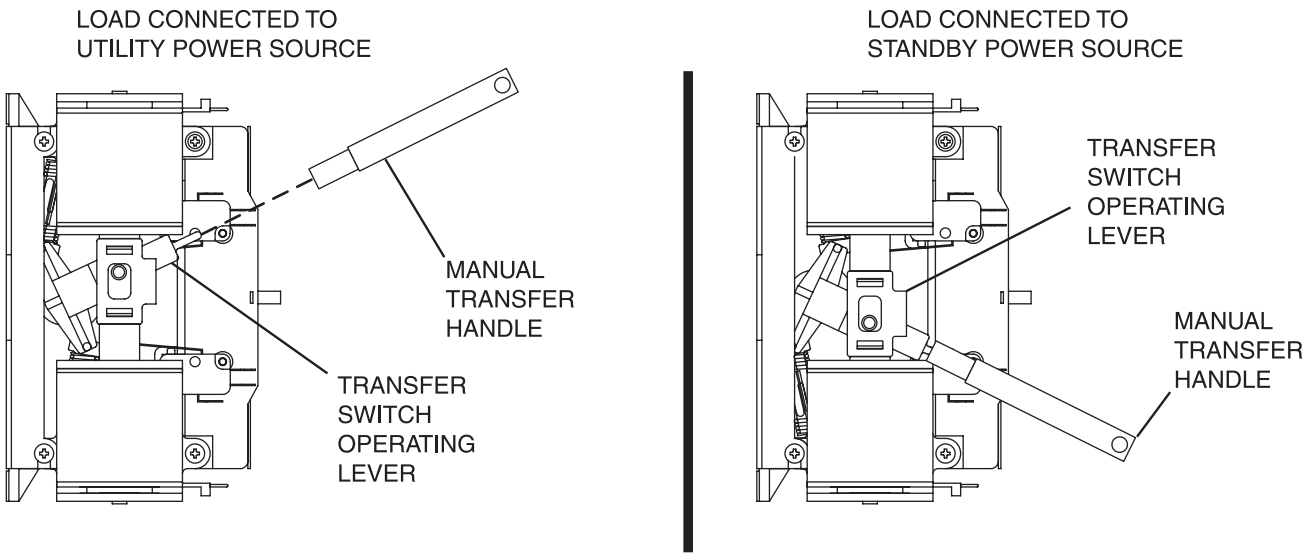

LOAD CONNECTED TO UTILITY POWER SOURCE
MANUAL TRANSFER HANDLE
TRANSFER SWITCH OPERATING LEVER
LOAD CONNECTED TO STANDBY POWER SOURCE
TRANSFER SWITCH OPERATING LEVER
MANUAL TRANSFER HANDLE

Figure 1. Manual Operation “V-Type” Switch

using the means provided (such as a utility main line circuit breaker).

⚠ DANGER ⚠

⚠ THE TRANSFER SWITCH IS NOW ELECTRICALLY "HOT." CONTACT WITH "HOT" PARTS WILL RESULT IN EXTREMELY HAZARDOUS AND POSSIBLY FATAL ELECTRICAL SHOCK. PROCEED WITH CAUTION.

5. Use an accurate AC voltmeter to check utility power source voltage across transfer switch terminals N1 and N2. Nominal line-to-line voltage should be 240 volts AC.
6. Check utility power source voltage across terminals N1 and the transfer switch neutral lug; then across terminal N2 and neutral. Nominal line-to-neutral voltage should be 120 volts AC.
7. When certain that utility supply voltage is compatible with transfer switch and load circuit ratings, turn OFF the utility power supply to the transfer switch.
8. On the generator panel, set the Auto-Off-Manual switch to MANUAL. The engine should crank and start.
9. Let the engine warm up for about five minutes to allow internal temperatures to stabilize. Then, set the generator main circuit breaker to its "ON" (or closed) position.

⚠ DANGER ⚠

⚠ PROCEED WITH CAUTION! GENERATOR POWER VOLTAGE IS NOW SUPPLIED TO THE TRANSFER SWITCH. CONTACT WITH LIVE TRANSFER SWITCH PARTS WILL RESULT IN DANGEROUS AND POSSIBLY FATAL ELECTRICAL SHOCK.

10. Connect an accurate AC voltmeter and a frequency meter across transfer switch terminal lugs E1 and E2. Voltage should be 242-252 volts; frequency should read about 61-63 Hertz.
11. Connect the AC voltmeter test leads across terminal lug E1 and neutral; then across E2 and neutral. In both cases, voltage reading should be 121-126 volts AC.
12. Set the generator main circuit breaker to its OFF (or open) position. Let the engine run at no-load for a few minutes to stabilize internal engine generator temperatures.
13. Set the generator Auto-Off-Manual switch to OFF. The engine should shut down.

NOTE: It is important that you do not proceed until you are certain that generator AC voltage and frequency are correct and within the stated limits. Generally, if both AC frequency and voltage are high or low, the engine governor requires adjustment. If frequency is correct, but voltage is high or low, the generator voltage regulator requires adjustment.

GENERATOR TESTS UNDER LOAD

To test the generator set with electrical loads applied, proceed as follows:

1. Set generator main circuit breaker to its OFF (or open) position.
2. Turn OFF all loads connected to the Transfer Switch Terminals T1 and T2.
3. Set the generator Auto-Off-Manual switch to OFF.
4. Turn off the utility power supply to the transfer switch, using the means provided (such as a utility main line circuit breaker).

⚠ WARNING ⚠

⚠ DO NOT ATTEMPT MANUAL TRANSFER SWITCH OPERATION UNTIL ALL POWER VOLTAGE SUPPLIES TO THE TRANSFER SWITCH HAVE BEEN POSITIVELY TURNED OFF. FAILURE TO TURN OFF ALL POWER VOLTAGE SUPPLIES WILL RESULT IN EXTREMELY HAZARDOUS AND POSSIBLY FATAL ELECTRICAL SHOCK.

5. Manually set the transfer switch to the STANDBY position, i.e., load terminals connected to the generator E1/E2 terminals. The transfer switch operating lever should be down.
6. Set the generator Auto-Off-Manual switch to MANUAL. The engine should crank and start immediately.
7. Let the engine stabilize and warm up for a few minutes.
8. Set the generator main circuit breaker to its ON (or closed) position. Loads are now powered by the standby generator.
9. Turn ON electrical loads connected to transfer switch T1 and T2. Apply an electrical load equal to the full rated wattage/amperage capacity of the installed generator.

10. Connect an accurate AC voltmeter and a frequency meter across terminal lugs E1 and E2. Voltage should be greater than 230 volts; frequency should be greater than 58 Hertz.
11. Let the generator run at full rated load for 20-30 minutes. Listen for unusual noises, vibration or other indications of abnormal operation. Check for oil leaks, evidence of overheating, etc.
12. When testing under load is complete, turn OFF electrical loads.
13. Set the generator main circuit breaker to its OFF (or open) position.
14. Let the engine run at no-load for a few minutes.
15. Set the Auto-Off-Manual switch to OFF. The engine should shut down.

CHECKING AUTOMATIC OPERATION

To check the system for proper automatic operation, proceed as follows:

1. Set generator main circuit breaker to its OFF (or open) position.
2. Check that the Auto-Off-Manual switch is set to OFF.
3. Turn off the utility power supply to the transfer switch, using means provided (such as a utility main line circuit breaker).
4. Manually set the transfer switch to the UTILITY position, i.e., load terminals connected to the utility power source side.
5. Turn on the utility power supply to the transfer switch, using the means provided (such as a utility main line circuit breaker).
6. Set the Auto-Off-Manual switch to AUTO. The system is now ready for automatic operation.
7. Turn OFF the utility power supply to the transfer switch.

With the Auto-Off-Manual switch at "AUTO," the engine should crank and start when the utility source power is turned off. After starting, the transfer switch should connect load circuits to the standby side. Let the system go through its entire automatic sequence of operation.

With the generator running and loads powered by generator AC output, turn ON the utility power supply to the transfer switch. The following should occur:

- After about six seconds, the switch should transfer loads back to the utility power source.
- About one minute after retransfer, the engine should shut down.

SETTING THE EXERCISE TIMER

The generator is equipped with an exercise timer. Once it is set, the generator will start and exercise once every seven days, on the day of the week and at the time of day you complete the following sequence. During this exercise period, the unit runs for approximately 12 minutes and then shuts down. Transfer of loads to the generator output does not occur during the exercise cycle.

A switch on the control panel (see Figure 1, Section 1.6) allows you to select the day and time for system exercise. To select the desired day and time of day, you must perform the following sequence at that time.

1. Verify that the Auto-Off-Manual switch is set to AUTO.
2. Hold down the set timer switch until the generator starts (approximately 10 seconds) and then release.
3. The generator will start and run for approximately 12 minutes and then shut down on its own. The exerciser will then be set to run at that time of day every week.

NOTE: The exerciser will only work in the AUTO mode and will not work unless this procedure is performed. The exerciser will need to be reset every time the 12 volt battery is disconnected and then reconnected. The exerciser WILL NOT work if dip switch 2 (Remote Not Auto) on the controller printed circuit board is "ON."

PART 6
DISASSEMBLY

Air-cooled, Prepackaged Automatic Standby Generators

Models:
6 kW NG, 7 kW LP
12 kW NG, 12 kW LP
13 kW NG, 15 kW LP

TABLE OF CONTENTS

PART	TITLE
6.1	Major Disassembly

MAJOR DISASSEMBLY

STATOR/ROTOR/ENGINE REMOVAL:

For stator removal, follow Steps 1-14. For rotor removal, follow Steps 1-15. For Engine removal follow Steps 1-16.

1. Remove door.
2. Set the Auto-Off-Manual switch to OFF. Disconnect battery cables. Remove Fuse F1. Remove the utility power source to the generator. Turn off fuel supply to the generator.
3. **Remove Control Panel Cover:** Using a 10 mm socket, remove the control panel cover. Remove two nuts located on back panel using a 7mm socket. Remove two control panel screws.
4. **Disconnect Stator Leads/Connectors:** Remove the stator leads (Wire 11 and Wire 44) from the main circuit breaker. Remove the stator leads (Wire 22 and Wire 33) from the neutral lug. Unplug connectors C1 and C2 from the control panel. For control panel removal only, remove Wires N1/N2 and Wires 23/194 from the terminal strip, and the ground and neutral wires from the control panel.
5. **Disconnect Fuel Hoses:** Remove the two fuel hoses at the air box assembly. Some models are equipped with an additional third fuel hose. Remove it also if equipped. Pull hoses back into the battery compartment. For control panel removal only remove Wire Nos. 0 and 14 from the fuel solenoid.
6. **Remove Front and Back Exhaust Enclosure Covers:** Using a 10mm socket, remove the five bolts and four nuts from the exhaust covers. Remove the covers. Remove the nut and bolt attaching to the roof left side folding support and bottom support bracket.
7. **Remove Exhaust Side Enclosure:** Using a 10mm socket with a 2 1/2" extension remove the four (4) bottom enclosure bolts, and six (6) side enclosure bolts. Remove the enclosure.

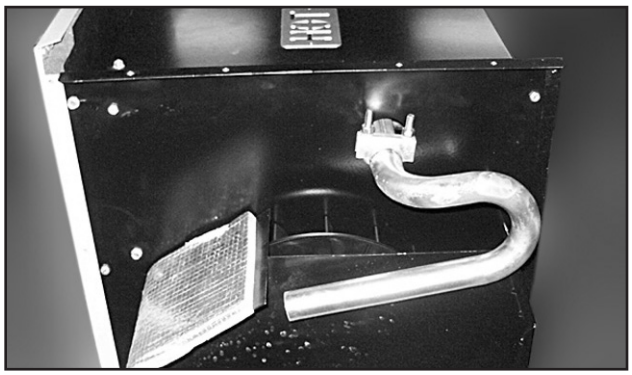


Figure 1. Exhaust Side Enclosure Removed

8. **Remove Exhaust Pipe:** Using a 13mm socket, loosen the exhaust clamp and remove the exhaust pipe.
9. **Remove Fan Housing Cover:** Using a 10 mm socket, remove the six (6) bolts from each side of the fan housing cover. Remove the fan housing cover.
10. **Remove Rotor Bolt:** Using a 9/16 socket, remove one rotor bolt.
11. **Remove Fan:** Attach a steering wheel puller to the fan using two (2) M8 X 1.25 bolts. Remove fan from rotor.

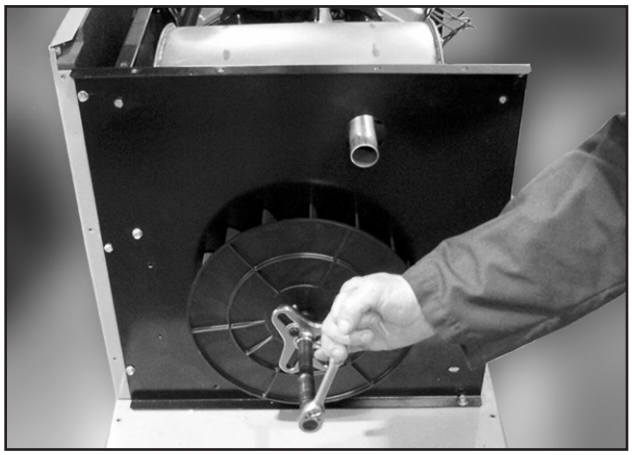


Figure 2. Using a Steering Wheel Puller to Remove Fan From Rotor

12. **Remove Muffler Box/Side Cover and Alternator panel Divider:** Using a 10mm socket, remove the three bolts from the top of the muffler box cover that attach to the muffler side cover, and two bolts from the side of the muffler box cover that attach to the alternator divider plate. Remove the muffler box cover.

    Remove the four bolts that attach the alternator divider panel. Three are connected on the left side to the back enclosure panel, and one is connected to the enclosure base on the bottom right corner.

Remove the two bolts attaching the muffler side cover to the back enclosure panel. They are located in the center of the back panel. Remove the alternator panel and muffler side cover as an assembly.

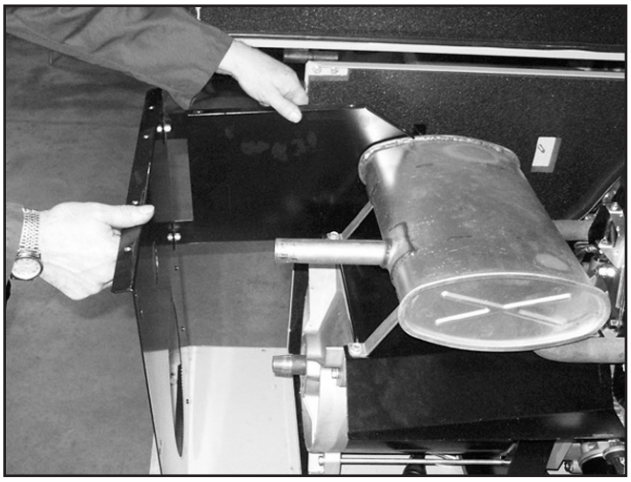


Figure 3

13. **Remove Muffler:** Using a 13mm socket, remove the four muffler hold down bolts. Remove the four exhaust manifold nuts. Remove the muffler and muffler base panel.

14. **Stator Removal:** Using a 13mm socket, remove the two nuts from the alternator mounting bracket/rubber mounts. Lift the back end of the alternator up and place a 2"x 4" piece of wood under the engine adapter.

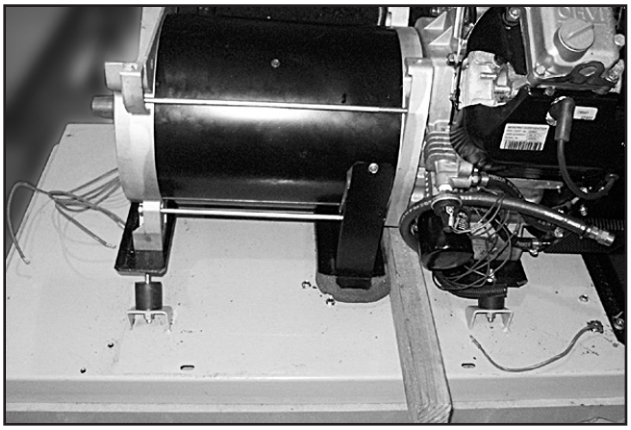


Figure 4. Engine Adapter Supported by 2"x4" Piece of Wood

Using a 1/4" socket, remove Wire 0 and Wire 4 from the brush assembly. Remove the two brush assembly hold down bolts. Remove the brushes.

Using a 13mm socket, remove the four stator hold down bolts. Using a small rubber mallet remove the rear bearing carrier. Remove the stator.

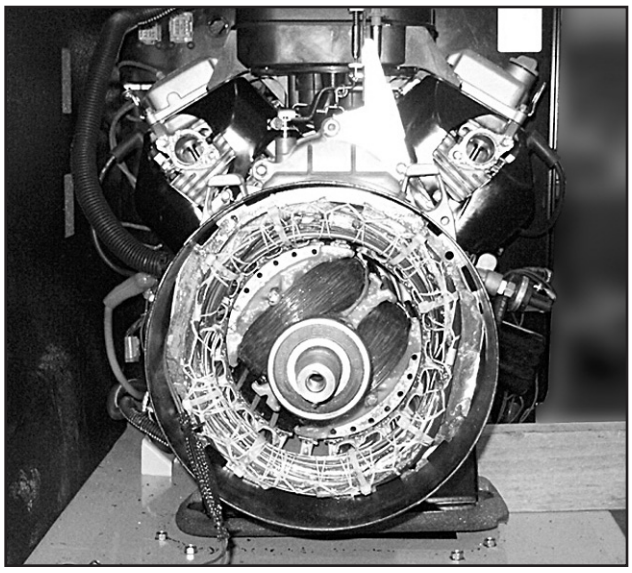


Figure 5. Rear Bearing Carrier Removed

Figure 6. Removing the Stator

15. **Rotor Removal:** Cut 2.5 inches from the rotor bolt. Slot the end of the bolt to suit a flat blade screwdriver. Slide the rotor bolt back through the rotor and use a screwdriver to screw it into the crankshaft. Use a 3" M12x1.75 bolt to screw into rotor. Apply torque to the 3" M12x1.75 bolt until taper breaks. If necessary, when torque is applied to 3" M12x1.75 bolt, use a rubber mallet on the end of the rotor shaft to break taper.

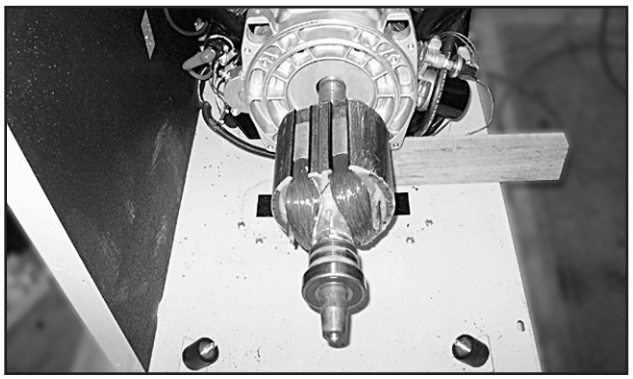


Figure 7. Removing the Rotor

16. **Remove Engine:** Using a 13mm socket, remove the two engine mount nuts, and ground wires. Remove the engine.
17. Reverse the previous steps to re-assemble.

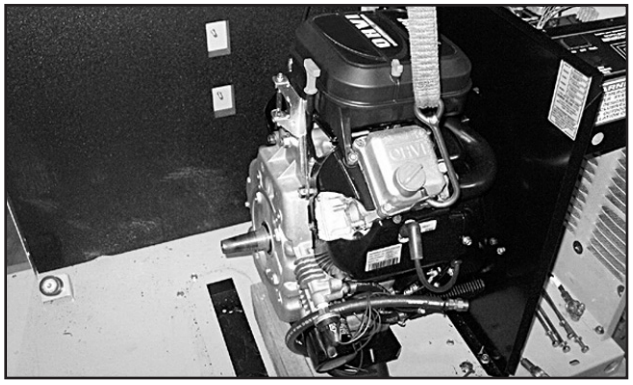


Figure 8. Removing the Engine

FRONT ENGINE ACCESS

1. Follow Stator/Rotor/Engine removal procedures, Steps 1-5.
2. **Control Panel Removal:** Using a 7mm socket remove the eight bolts from male connectors C1 and C2. Remove connectors engine divider panel.

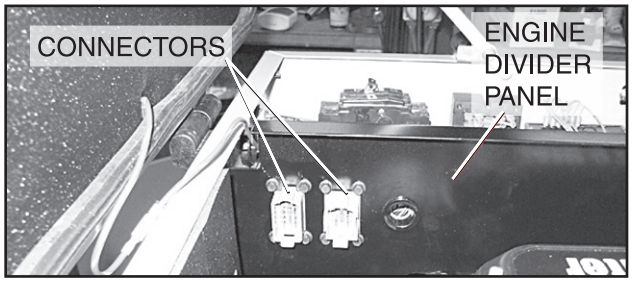


Figure 9. C1 and C2 Connectors Located on the Engine Divider Panel

Using a 10mm socket, remove the six (6) nuts attaching the control panel to the side/back enclosure and the engine divider panel. Remove the two (2) nuts connected to the back enclosure located on the top side of control panel. Remove the two (2) nuts located underneath the middle of the control panel, connecting to the back/side enclosure and the engine divider panel. Remove the two (2) nuts from the front top side of the control panel, connecting to the back/side enclosure and the engine divider panel. Remove the control panel.

3. **Remove Engine Divider Panel:** Using a 10mm socket, remove the remove the two (2) nuts attached to the back enclosure. Remove the two bolts attached to the base enclosure. Remove the engine divider panel.
4. **Remove Intake manifolds:** Using a 6mm allen wrench, remove the four (4) socket head cap screws from the intake manifolds. Remove the intake manifolds. Remove the air intake snorkel.
5. **Remove Air Box:** Using a 5/32 allen wrench, remove the four (4) air box allen head shoulder bolts. While removing the air box remove the four rubber washers and disconnect the throttle linkage and anti-lash spring.
6. **Unbolt Oil Cooler:** Using a 10mm socket, remove the four (4) oil cooler bolts.
7. **Remove Blower Housing:** Using an 8mm socket, remove the nine (9) bolts around the blower housing. Remove the blower housing.
8. **Remove flywheel:** Use a 36mm socket, a steering wheel puller, two (2) M8x1.25 bolts and a 13 mm socket. Remove the flywheel hex nut, remove the fan plate and fan. Install the puller using the M8x1.25 bolts and remove the flywheel.

TORQUE REQUIREMENTS (UNLESS OTHERWISE SPECIFIED)

CYLINDER HEAD BOLTS	22 FT-LBS
FLYWHEEL NUT	50 FT-LBS
STATOR BOLTS	12 FT-LBS
ROTOR BOLT	30 FT-LBS
ENGINE ADAPTER	25 FT-LBS
EXHAUST MANIFOLD	18 FT-LBS
INTAKE MANIFOLD (TO CYLINDER HEAD)	22 FT-LBS
M5-0.8 TAPTITE SCREW INTO ALUMINUM	25-50 IN-LBS
M5-0.8 TAPTITE SCREW INTO PIERCED HOLE	25-50 IN-LBS
M6-1.0 TAPTITE SCREW INTO ALUMINUM	50-96 IN-LBS
M6-1.0 TAPTITE SCREW INTO PIERCED HOLE	50-96 IN-LBS
M6-1.0 TAPTITE SCREW INTO WELDNUT	50-96 IN-LBS
M8-1.25 TAPTITE SCREW INTO ALUMINUM	12-18 FT-LBS
M6-1.0 NYLOK NUT ONTO STUD	16-65 IN-LBS

NOTE: TORQUES ARE DYNAMIC VALUES WITH ±10% TOLERANCE UNLESS OTHERWISE NOTED.

PART 7
ELECTRICAL DATA

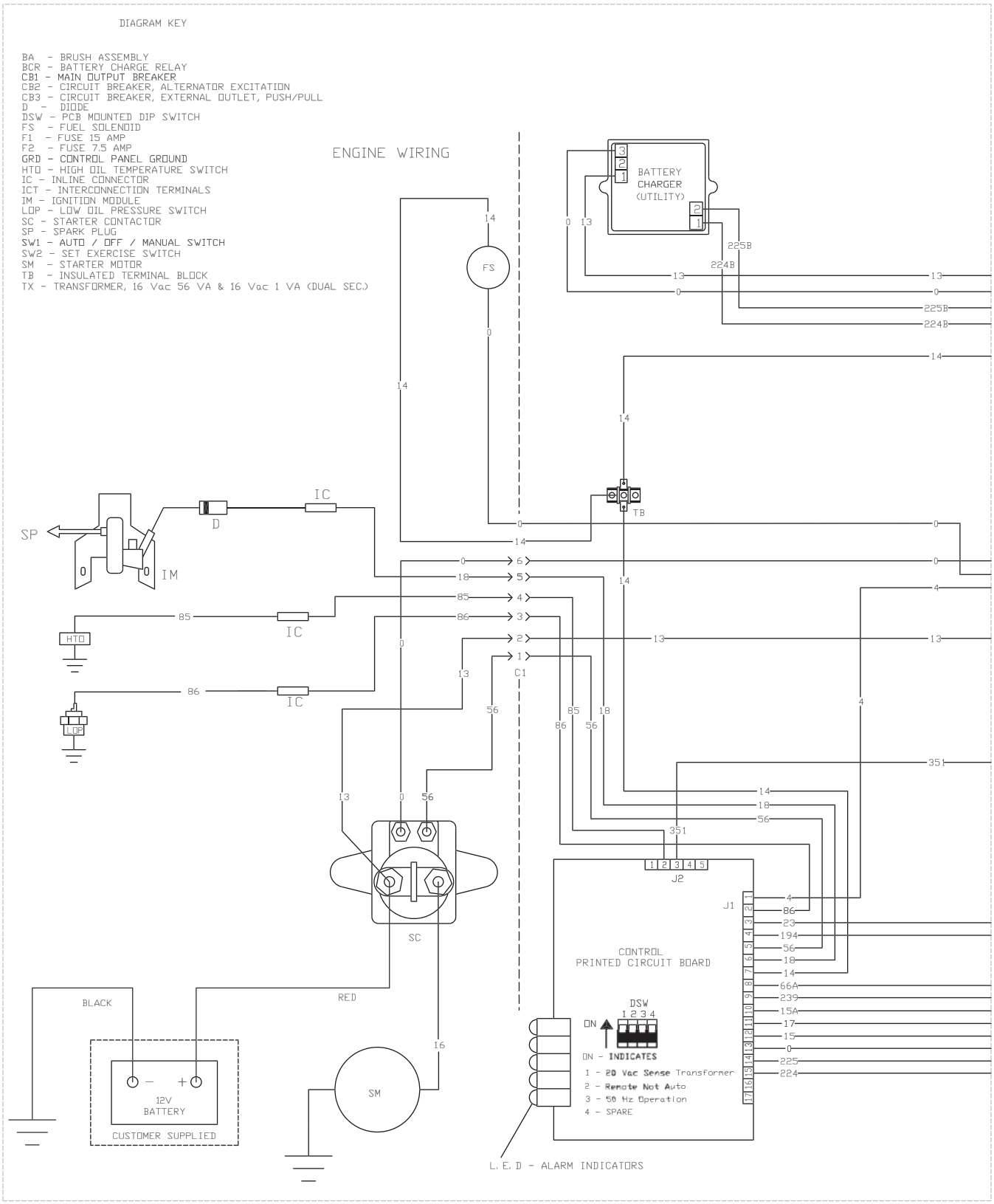
Air-cooled, Prepackaged Automatic Standby Generators

Models:
6 kW NG, 7 kW LP
12 kW NG, 12 kW LP
13 kW NG, 15 kW LP

TABLE OF CONTENTS

DWG #	TITLE
0D9014-B	WIRING DIAGRAM, 7 KW HSB
0D9015-B	SCHEMATIC, 7 KW HSB
0D9016-B	WIRING DIAGRAM, 12 & 15 KW HSB
0D9017-B	SCHEMATIC, 12 & 15 KW HSB
0E7687A	WIRING DIA., 8 CIRCUIT LOAD CENTER
0E7815A	SCHEMATIC, 8 CIRCUIT LOAD CENTER
0E7687	WIRING DIA., 10/12 CIRC. LOAD CENTER
0E7815	SCHEMATIC, 12/12 CIRC. LOAD CENTER

DRAWING #0E9014 (1 OF 2)



WIRING DIAGRAM, 7 KW HOME STANDBY

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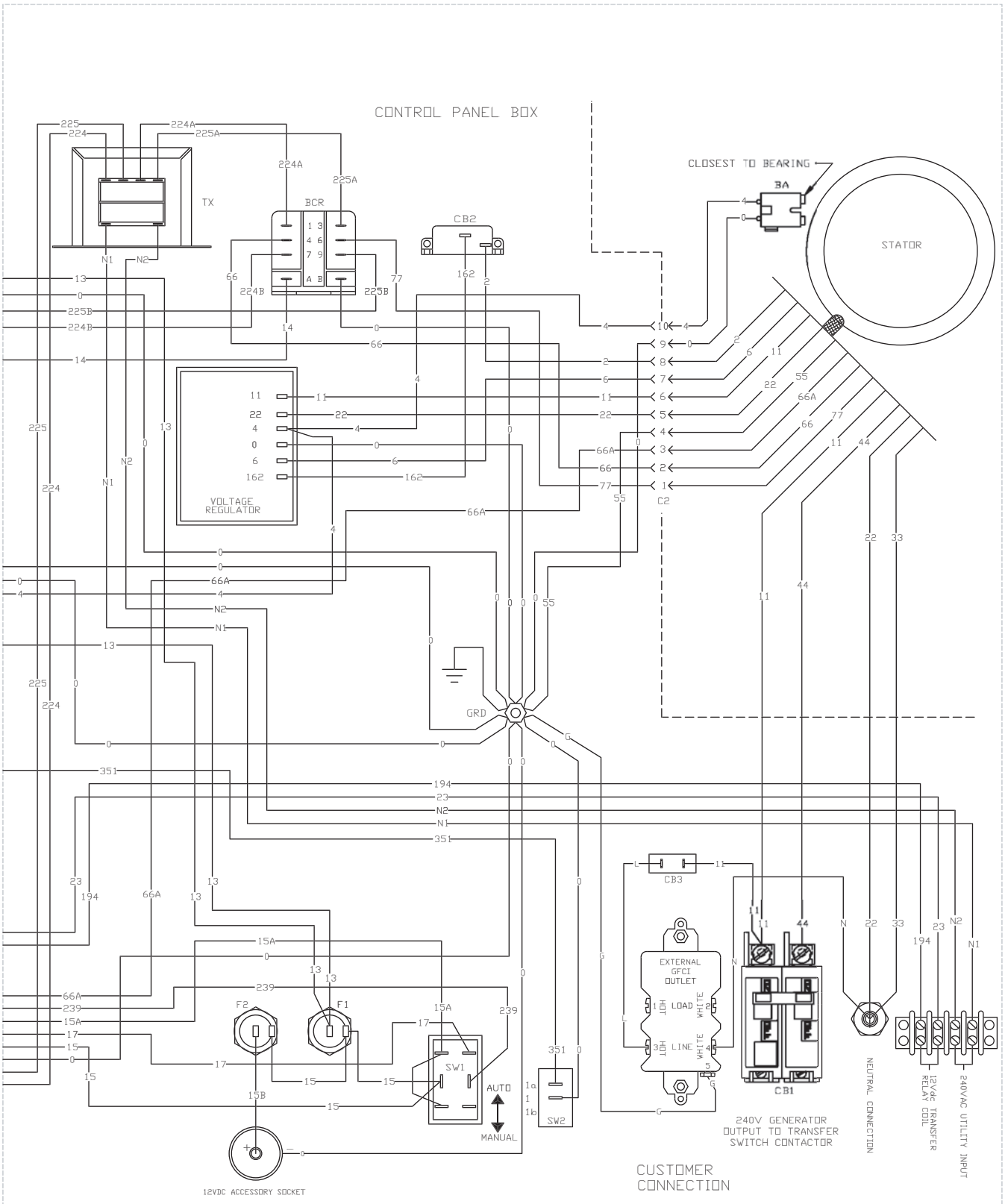

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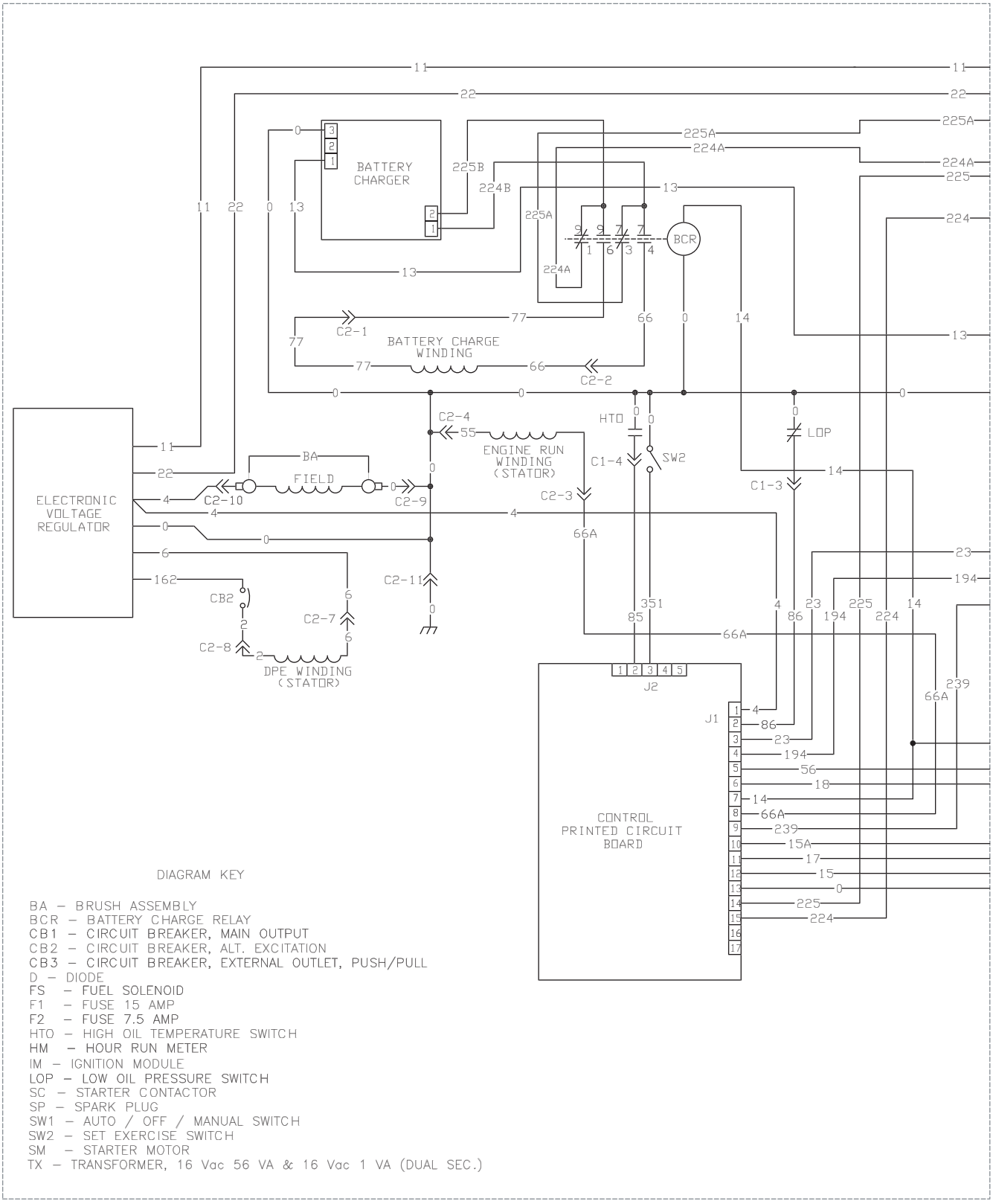

SCHEMATIC - DIAGRAM

REVISION: *

DATE: 11/03/03

DRAWING #: 0E9015

SCHEMATIC, 7 KW HOME STANDBY

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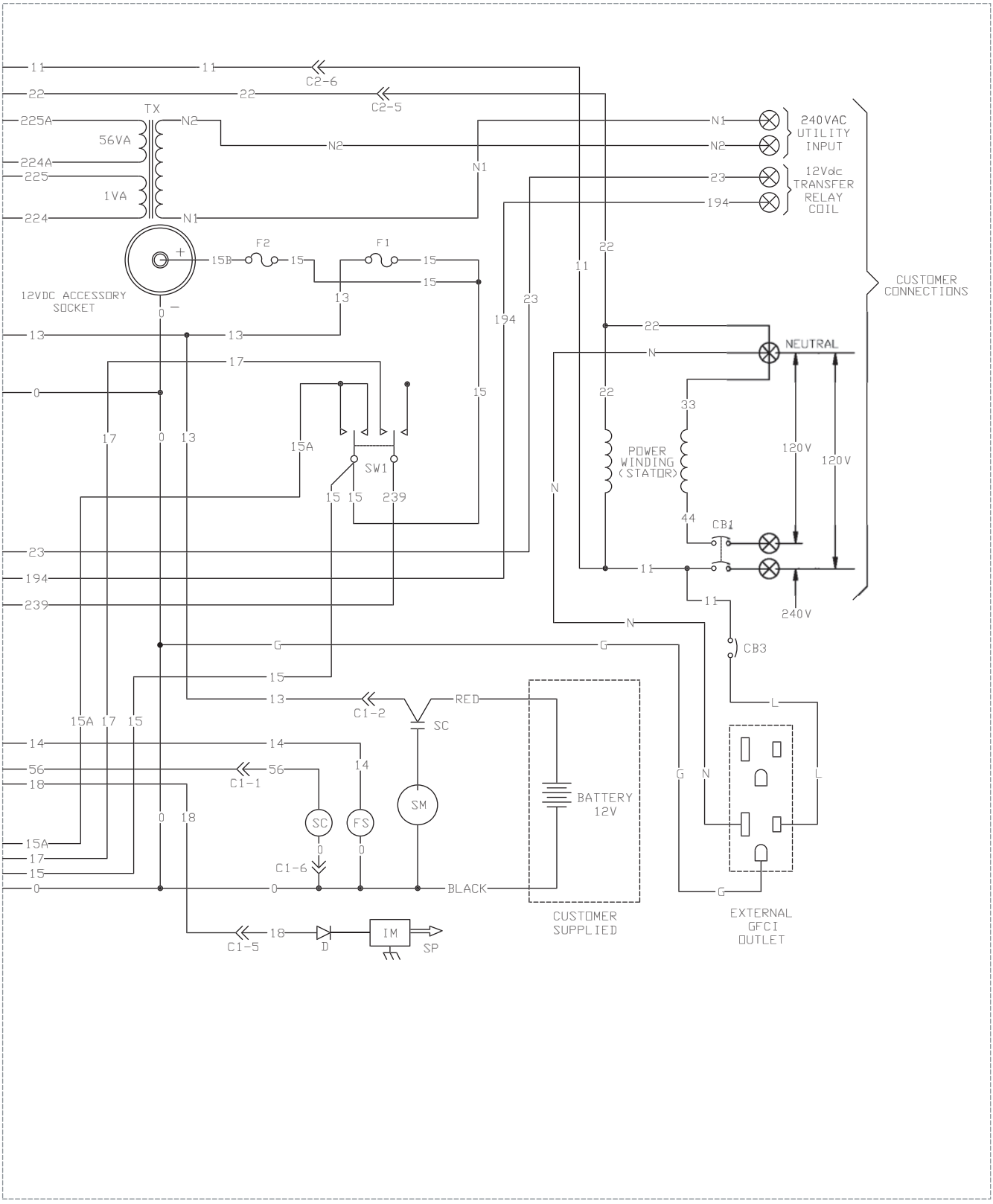

SCHEMATIC - DIAGRAM

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DATE: 11/03/03

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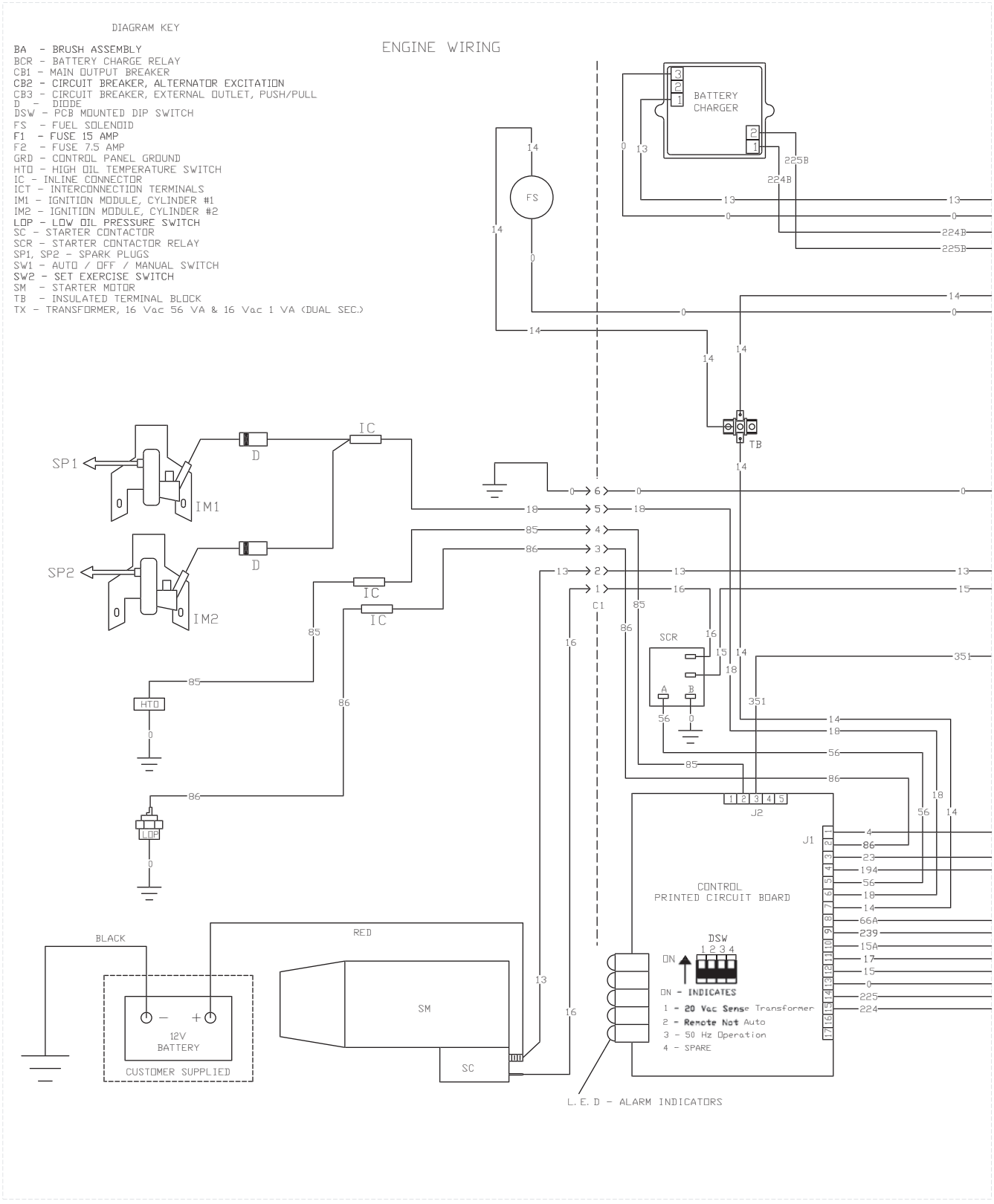

WIRING DIAGRAM, 12 & 15 KW HOME STANDBY

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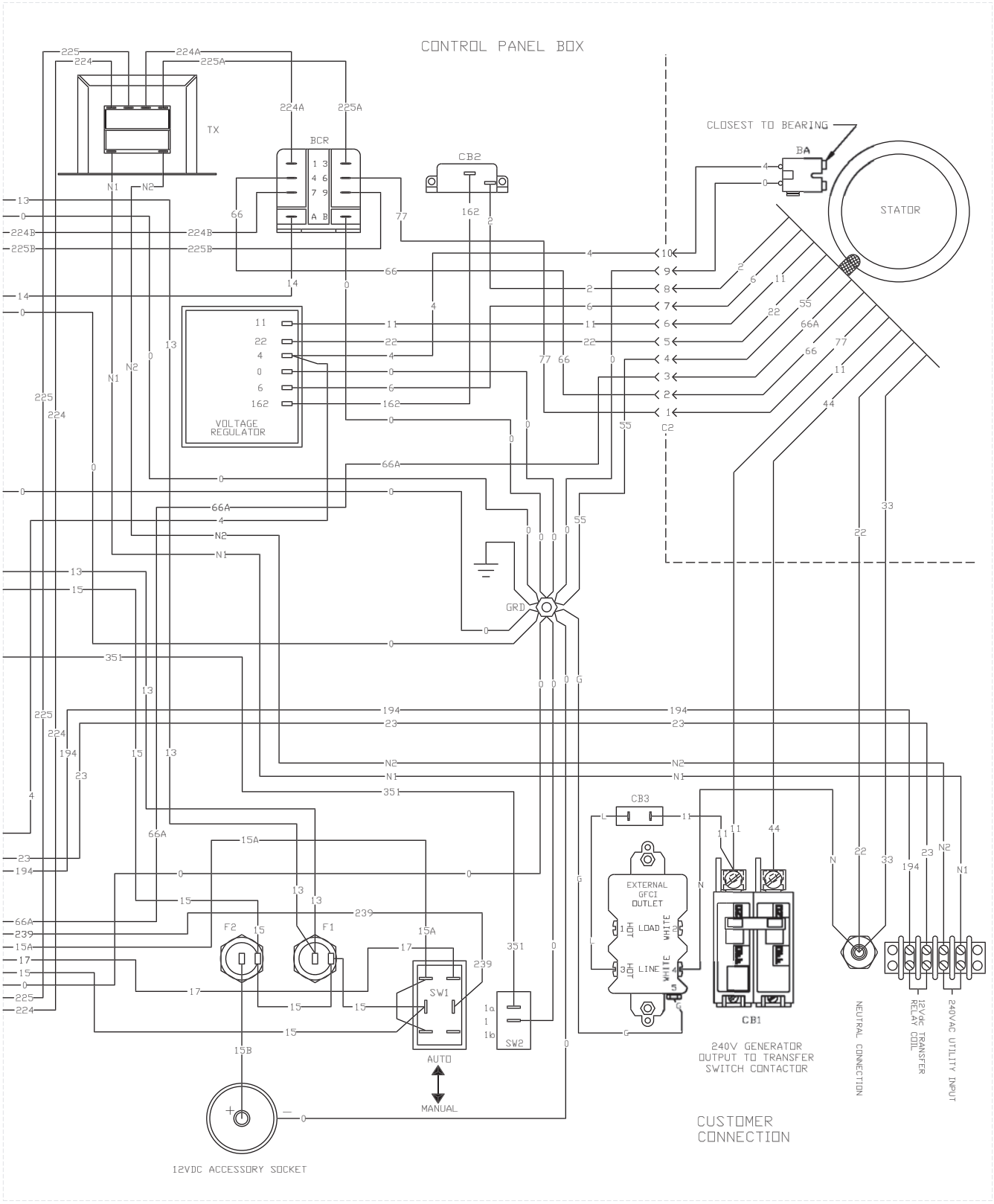

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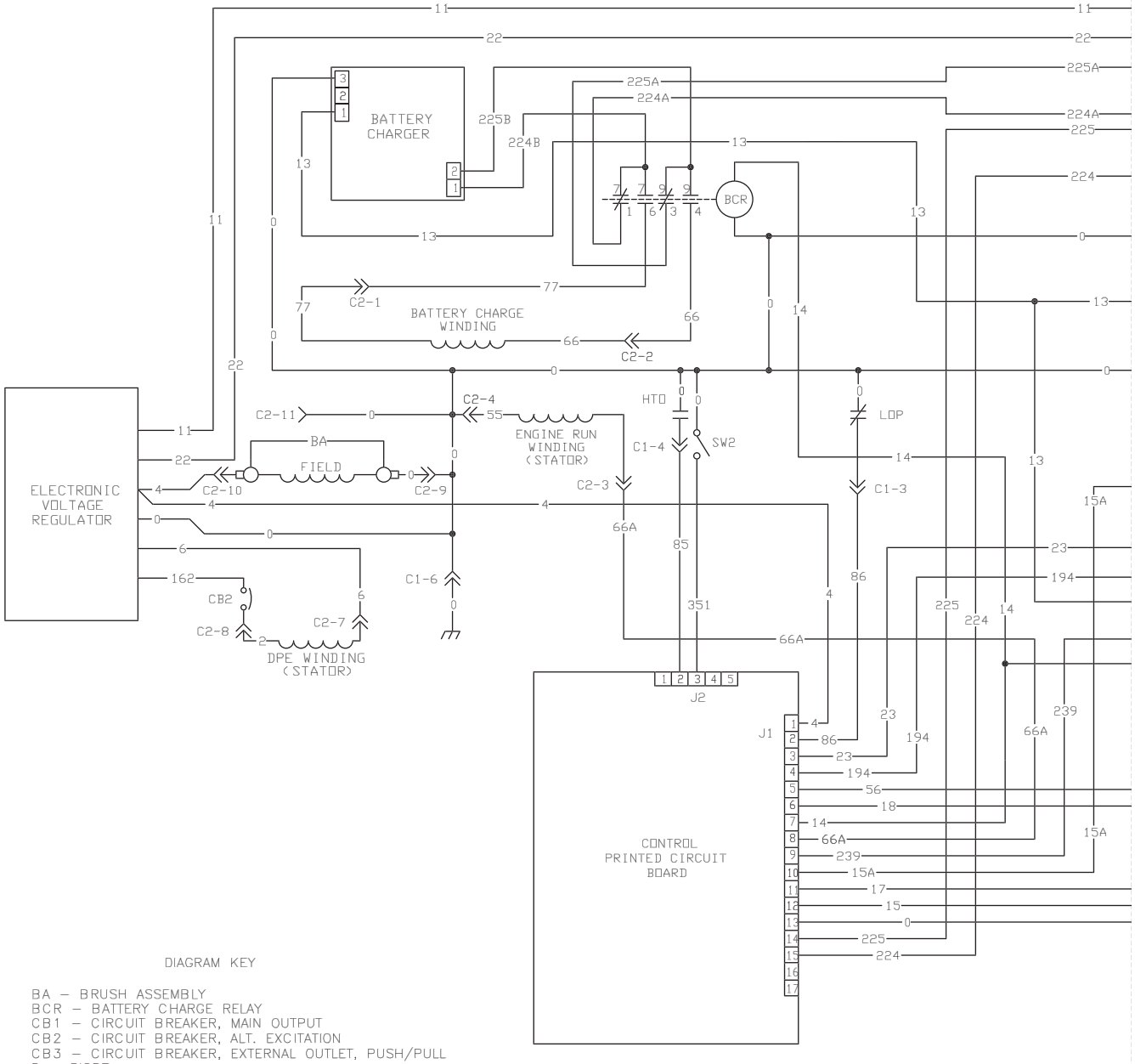


DIAGRAM KEY

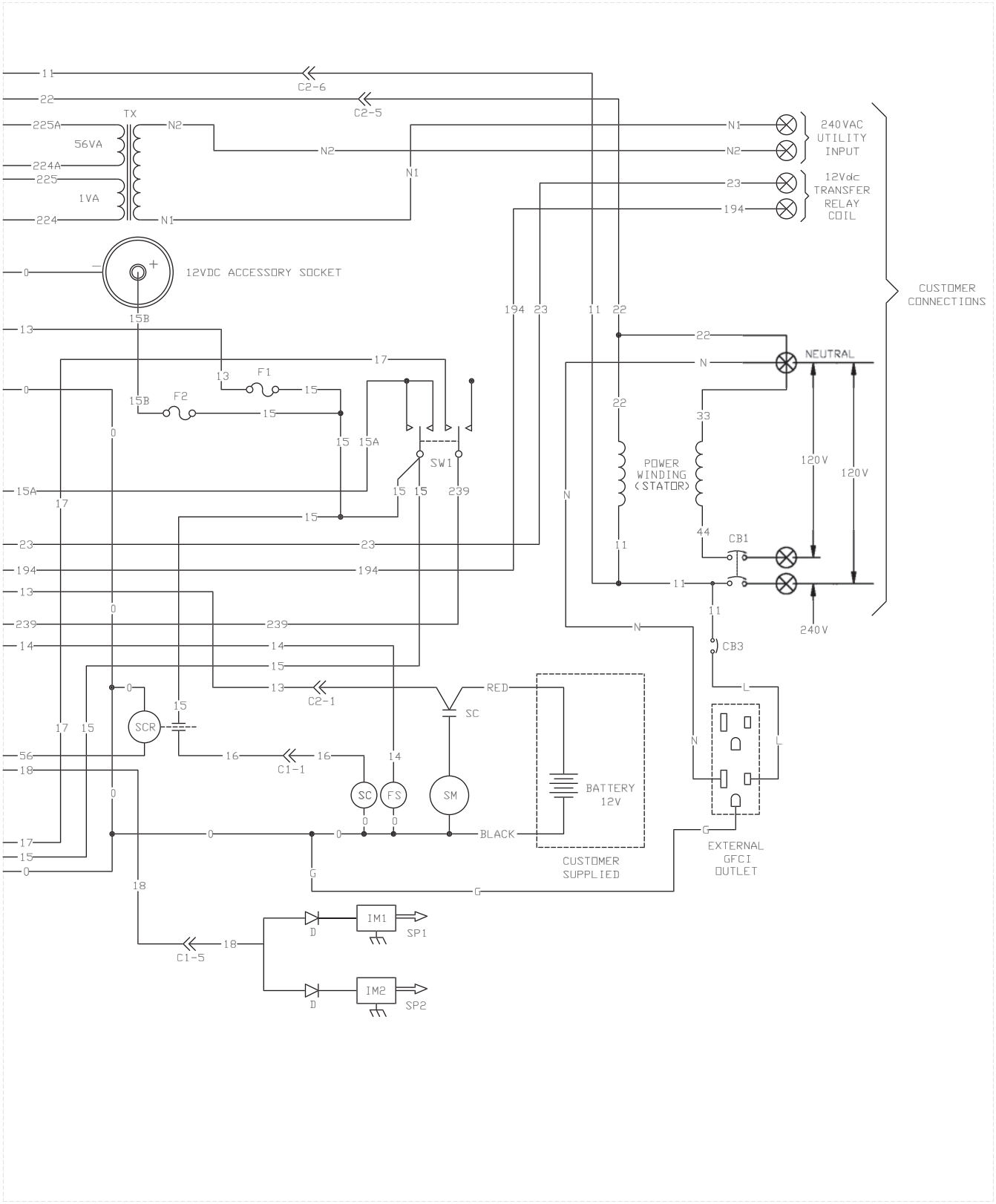
BA – BRUSH ASSEMBLY
BCR – BATTERY CHARGE RELAY
CB1 – CIRCUIT BREAKER, MAIN OUTPUT
CB2 – CIRCUIT BREAKER, ALT. EXCITATION
CB3 – CIRCUIT BREAKER, EXTERNAL OUTLET, PUSH/PULL
D – DIODE
FS – FUEL SOLENOID
F1 – FUSE 15 AMP
F2 – FUSE 7.5 AMP
HTO – HIGH OIL TEMPERATURE SWITCH
IM1 – IGNITION MODULE, CYLINDER #1
IM2 – IGNITION MODULE, CYLINDER #2
LOP – LOW OIL PRESSURE SWITCH
SC – STARTER CONTACTOR
SCR – STARTER CONTACTOR RELAY
SP1, SP2 – SPARK PLUGS
SW1 – AUTO / OFF / MANUAL SWITCH
SW2 – SET EXERCISE SWITCH
SM – STARTER MOTOR
TX – TRANSFORMER, 16 Vac 56 VA & 16 Vac 1 VA (DUAL SEC.)

SCHEMATIC - DIAGRAM

REVISION: *
DATE: 11/03/03

HSB
DRAWING #: 0E9017

DRAWING #0E9017 (2 OF 2)



SCHEMATIC - DIAGRAM

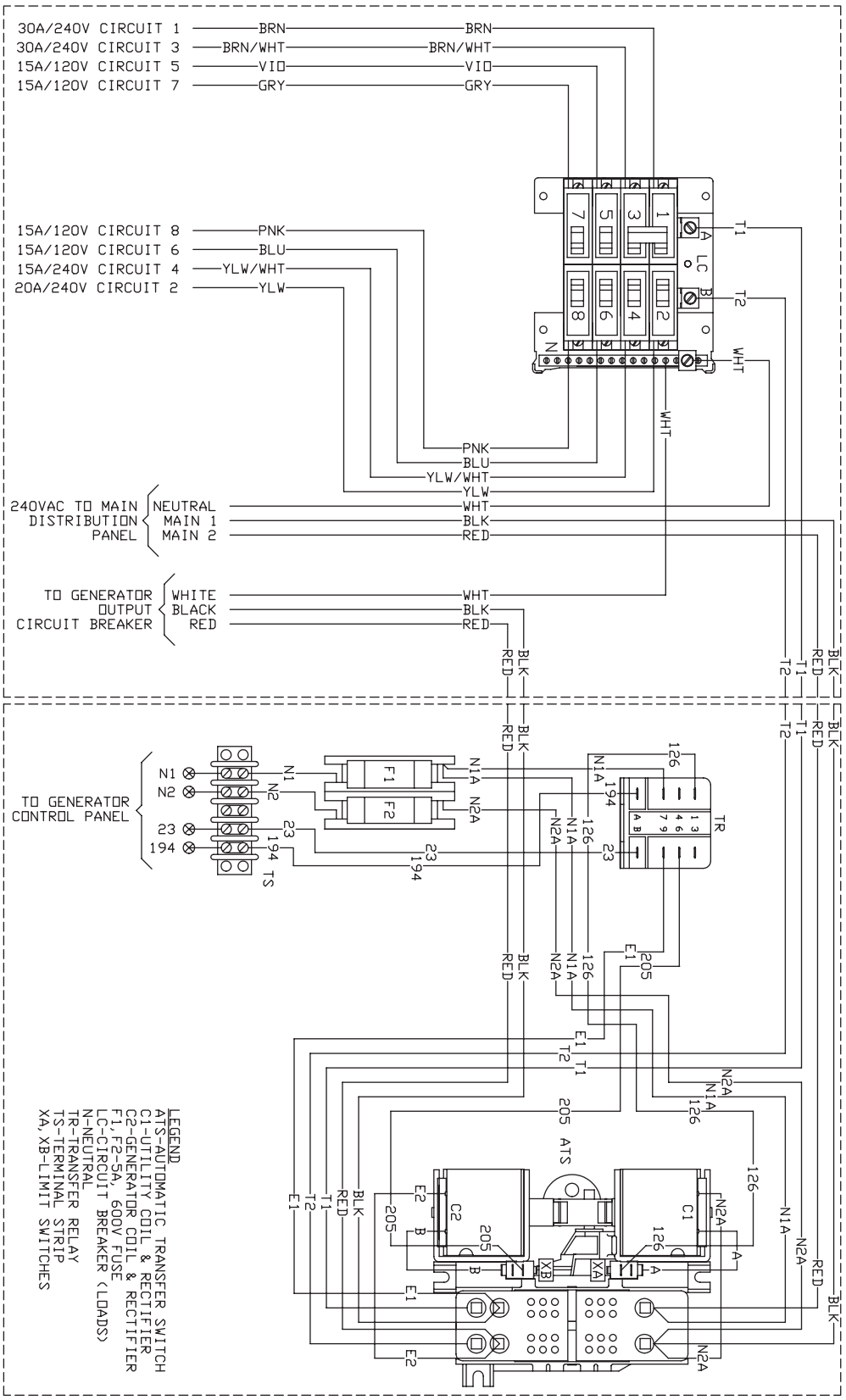
REVISION: *

HSB

DATE: 11/03/03

DRAWING #: 0E9017

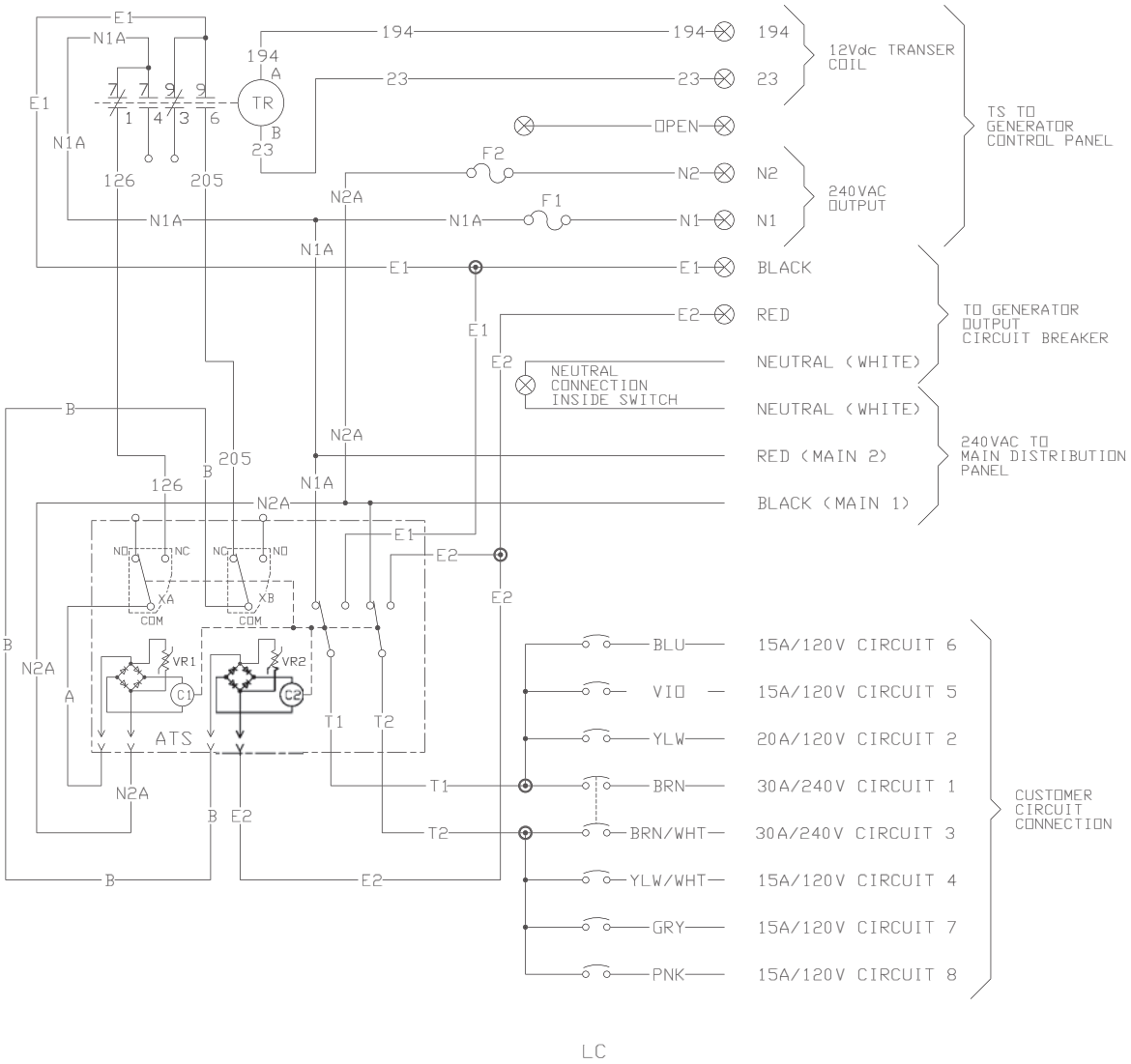
DRAWING #0E7687A



WIRING DIAGRAM,
HSB X-FER SWITCH, 8 CIR.

0E7687A

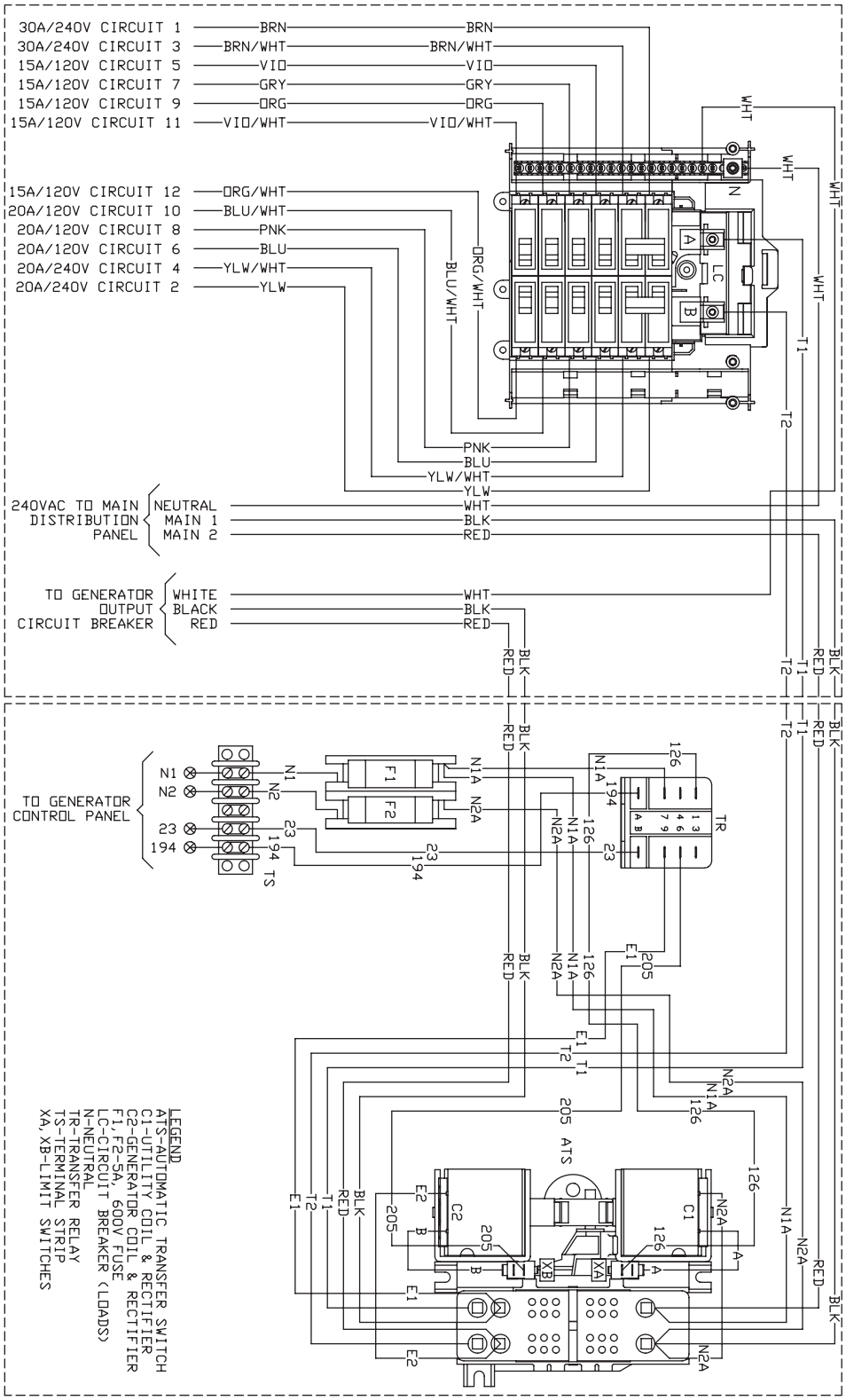
DRAWING #0E7815A



LEGEND
ATS-AUTOMATIC TRANSFER SWITCH
C1-UTILITY COIL & RECTIFIER
C2-GENERATOR COIL & RECTIFIER
F1, F2-5A, 600V FUSE
LC-CIRCUIT BREAKER (LOADS)
TR-TRANSFER RELAY
TS-TERMINAL STRIP
XA, XB-LIMIT SWITCHES

SCHEMATIC DIAGRAM
HSB X-FER SWITCH, 8 CIR. 0E7815A

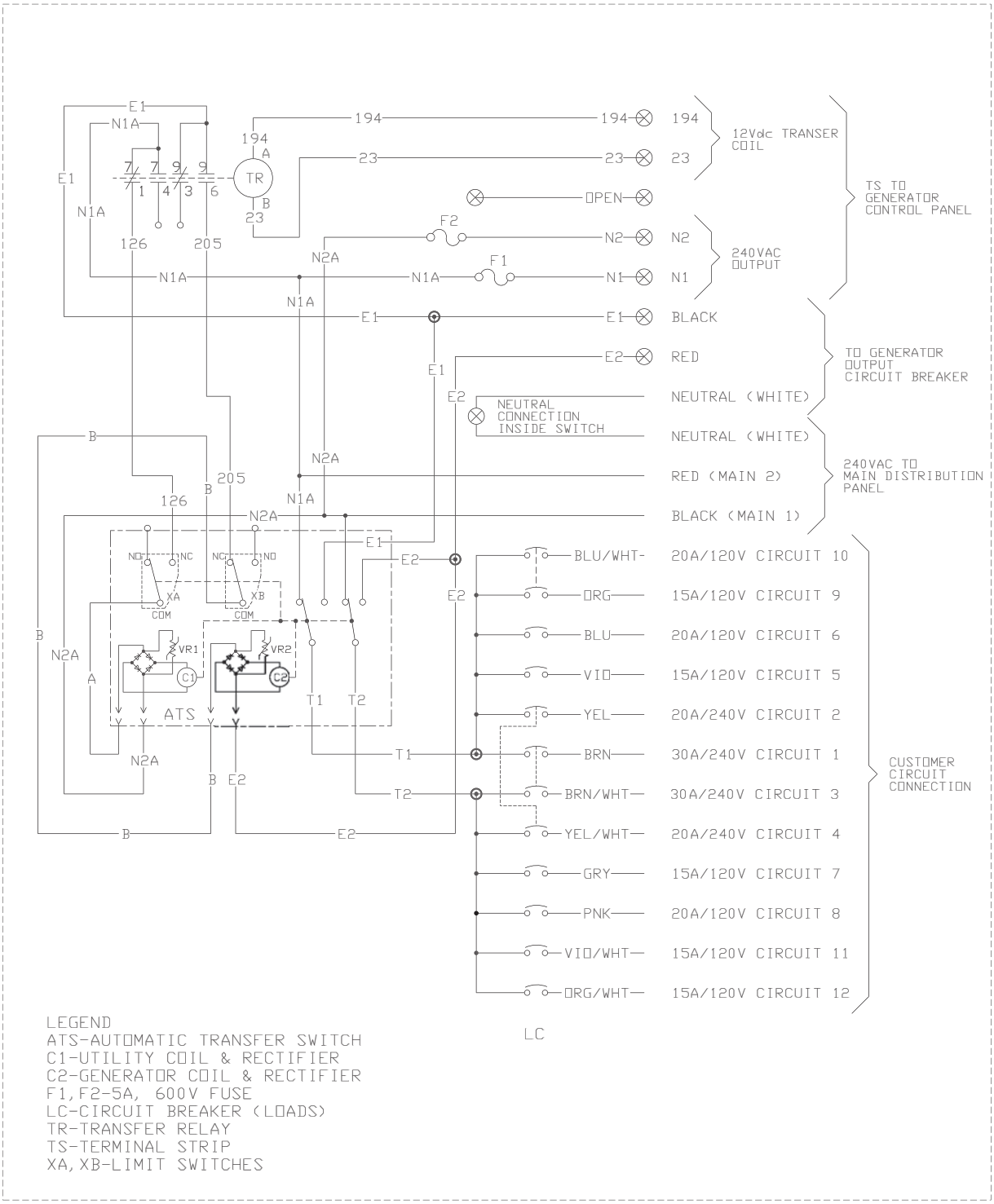
DRAWING #07687



WIRING DIAGRAM,
HSB X-FER SWITCH, 12 CIR.

0E7687

DRAWING #0E7815



SCHEMATIC DIAGRAM
HSB X-FER SWITCH, 12 CIR. 0E7815

ELECTRICAL FORMULAS

TO FIND	KNOWN VALUES	1-PHASE	3-PHASE
KILOWATTS (kW)	Volts, Current, Power Factor	$\frac{E \times I}{1000}$	$\frac{E \times I \times 1.73 \times PF}{1000}$
KVA	Volts, Current	$\frac{E \times I}{1000}$	$\frac{E \times I \times 1.73}{1000}$
AMPERES	kW, Volts, Power Factor	$\frac{kW \times 1000}{E}$	$\frac{kW \times 1000}{E \times 1.73 \times PF}$
WATTS	Volts, Amps, Power Factor	Volts x Amps	E x I x 1.73 x PF
NO. OF ROTOR POLES	Frequency, RPM	$\frac{2 \times 60 \times Frequency}{RPM}$	$\frac{2 \times 60 \times frequency}{RPM}$
FREQUENCY	RPM, No. of Rotor Poles	$\frac{RPM \times Poles}{2 \times 60}$	$\frac{RPM \times Poles}{2 \times 60}$
RPM	Frequency, No. of Rotor Poles	$\frac{2 \times 60 \times Frequency}{Rotor\ Poles}$	$\frac{2 \times 60 \times Frequency}{Rotor\ Poles}$
kW (required for Motor)	Motor Horsepower, Efficiency	$\frac{HP \times 0.746}{Efficiency}$	$\frac{HP \times 0.746}{Efficiency}$
RESISTANCE	Volts, Amperes	$\frac{E}{I}$	$\frac{E}{I}$
VOLTS	Ohm, Amperes	I x R	I x R
AMPERES	Ohms, Volts	$\frac{E}{R}$	$\frac{E}{R}$

E = VOLTS I = AMPERES R = RESISTANCE (OHMS) PF = POWER FACTOR

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